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OF
BONE AND JOINT SURGERY

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We are also anxious to report the Proceedings of Colleges, Universities, Societies and Associations in every part of the world in so far as they contribute to the advance of orthopaedic surgery. A measure of international co-operation in publication has already been achieved and this will be fostered and, we hope, increased.

Manuscripts offered for publication in the British volume should be addressed to the Editor, Journal of Bone and Joint Surgery, Ludgate House, Fleet Street, London. The Editorial Secretary of the Board is at the service of authors, and will assist in any way she can. Manuscripts offered for publication in the American volume should be addressed to the Editor, Journal of Bone and Joint Surgery, 8 The Fenway, Boston 15, Massachusetts.

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GALLIE, W. E. (1948): Recurrent Dislocation of the Shoulder. Journal of Bone and Joint Surgery, **30-B**, 6.

The names of Journals should be given in full; it is not proposed to adopt the "World List" of abbreviations. Every bibliography and list of references will be checked by the Editor, but much delay will be avoided if authors would be good enough to pay careful attention to accuracy.

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The Journal of
Bone and Joint Surgery

EDITORIALS

DISABILITIES OF THE HIP JOINT

The mere variety of procedures advocated for the operative treatment of osteoarthritis of the hip and for other conditions causing pain and instability is itself a sure indication that no one operation is uniformly successful. The series of articles in this number of the Journal confirm this trite observation. The hip now rivals the spine, the shoulder and the hallux for the number of operations designed for the relief of pain, correction of deformity and securing of stability in these regions. And there will be more to come, for it seems unlikely that there will be a metabolic treatment for degenerative joint changes comparable with treatment beginning to appear possible for the arthrites of the rheumatoid group.

Four main procedures are in common use—denervation, displacement osteotomy, arthrodesis and arthroplasty. All owe their success, probably, to their capacity to relieve stretching of the capsule and synovial membrane, often by means of temporary ablation. Of the three main methods of denervating the joint — neurectomy, cordotomy and capsulectomy—the last is increasingly favoured in some countries and appears the best of an unimpressive trio. Possibly it has a limited application in elderly people who cannot withstand any greater surgical adventure, especially when pain is severe but there is reasonable range of movement. In their admirable article, Osborne and Fahrni have at last explained how the displacement osteotomy advocated by the late T. P. McMurray may help by redistribution of the stresses acting on the hip. Though a much more useful operation than many surgeons have thought, it has two defects: it must be followed by prolonged immobilisation in plaster of Paris, which causes stiffness of the knee; and it alters the configuration of the upper end of the femur. This second effect makes any later reconstructive procedure difficult or impossible.

Perhaps the greatest controversy ranges over the relative merits of arthroplasty and arthrodesis. Even if there was agreement on this issue, still there would be arguments about the merits of this or that method. When both hips are involved it is now generally agreed, however, that arthroplasty is the procedure of choice. There are few who will deny that in the past quarter of a century the greatest single contribution to reconstructive surgery of the hip has been the painstaking work of Smith-Petersen. Most surgeons agree that " cup " arthroplasty, carefully performed and followed by intensive and thorough post-operative exercises, is, so far, the best arthroplasty for many hip conditions. Indeed, it might be cautiously prophesied that an operation of this kind—improved, it may be, in matters of technique and materials—will ultimately be the best solution for most chronic hip afflictions. It must be admitted, however, that up to now, in Great Britain, excision of the femoral head and neck—with or without an osteotomy as described by Batchelor—is usually found a

better treatment for stiff hips of ankylosing spondylitis than the more formal arthroplasties. An operation like that advocated by Gruca can hardly ever have more than a limited application to a few bizarre deformations. The replacement of the femoral head by a plastic mould, as described by the Judets and by others, is still *sub judice* during more time for proper evaluation. It is difficult to believe that any material which does not eventually blend with its host will remain attached firmly for long, although, possibly, the junction of the bone and prosthesis is so close to the axis of movement that there is not sufficient strain to loosen the " new " femoral head. The published results have been most encouraging when the procedure has been used in treating ununited fractures of the neck of the femur in old people. Perhaps it will transpire that this operation, which imposes less strain on the patient than most other surgical procedures on the hip, has a place in the treatment of those with a short expectancy of life and grossly disabled by osteoarthritis or ununited fractures of the femoral neck. But it surely is unwise, to say no more, to subject young people with lesions capable—though admittedly not easily capable—of being dealt with by other means to this procedure while it is still in the relatively experimental stage.

A single hip soundly fused by bone in the neutral position allows reasonably good function. For stability there is no operation to touch it. But fusion is not always easy to achieve, and the long period of post-operative immobilisation in plaster of Paris makes for difficulty in mobilising the knee. It may be that operations fulfilling Brittain's compression principles are most likely to produce sound bony fusion. Many surgeons accustomed to the anatomical perfections of the anterior Smith-Peterson approach will be gratified to learn, from Kirkaldy-Willis's beautifully illustrated article in this number of the Journal, that ischio-femoral arthrodesis can be accomplished via this route. This article will assuage those who are unaccustomed to a posterior approach and also those who fear (some think groundlessly) for the safety of the sciatic nerve in Brittain's lateral approach, which he and his associates still employ with confidence and enviable competence. All of us who are disturbed by the difficult problem of the stiff knee following many weeks of immobilisation in a spica will hope that the Norwich V-arthrodesis, announced by Howard and Brittain at the recent meeting of the British Orthopaedic Association, will live up to its original promise of making immobilisation of the knee unnecessary after this operation.

The correct method of securing the best result in all children with congenital dislocation of the hip is still elusive—an observation confirmed by the depressing long-term results now reported by Platou after open reduction. Many questions still require answers. Does the " shelf " operation really do much more than produce an occasional satisfying radiograph? Is it possible that the magnificent anatomical and clinical studies, notably those of Putti and his colleagues, require repetition less than re-interpretation? It would seem that once again attention is being directed to the role of excessive anteversion of the femoral head and neck. " Rotation osteotomy " after closed or open reduction is perhaps an operation desirable more often than has yet been acknowledged in this country.

Reflection on hip-joint surgery suggests much that is worth emphasis. Since no single procedure can guarantee success, operations which so deform the upper end of the femur that future reconstructive surgery is impossible should be abandoned or reserved for exceptional circumstances. No procedure is completely satisfactory when it requires such rigorous post-operative splinting of the limb that movement of the knee is jeopardised. A stiff hip is little disability; a stiff hip *and knee* in the same limb are among the severest. Clearly, we must continue to strive for the ideal—a stable hip joint with a painless range of adequate movement. All will hope that the British Orthopaedic Association's ambitious investigation, with the help of a Nuffield Foundation Grant, into the results of arthroplasties performed in Great Britain will yield conclusions of value in the achievement of this ideal.

H. OSMOND-CLARKE.

THE APPROACH TO THE HIP JOINT

Orthopaedic surgeons have the good fortune to follow a craft as well as to encompass a science. Like other craftsmen, we have often two ways at least of doing the same job, the success of which is dependent upon the character and integrity of the man. "Approaches" are for us both physical and psychological: in the case of the hip joint it seems clear that there is more than one good method and that, for the sake of those we train, we should keep an open mind.

On the continent of Europe there has been an almost rigid adherence to the methods of Kocher, Langenbeck and Ollier, with exposures of the hip joint from the posterior or lateral aspect. Though some surgeons use the Murphy approach, there is in the English-speaking world a greater tendency to follow the anterior Smith-Petersen approach. For us in Great Britain, Foley has recently drawn attention to the advantages of a posterior exposure for ischio-femoral arthrodesis. In this number of the Journal, Alexander Gibson describes in greater detail his use of the Kocher-Langenbeck exposure during thirty-five years. Gibson's advocacy is so persuasive that when the present writer first read this paper he decided to try one case, even though tempered by the natural doubt inculcated by a conservative upbringing. There was, however, *no* doubt when the operation had been done, and one immediately wondered why Kocher's approach had gained the reputation—which it has in America and Britain—of being sanguinous and shocking. Such was the ease that for the last thirty cases it has been the method of choice. Haemostasis is not required, for there is no bleeding. Dislocation of the femoral head is so easy that there is no shock. Transfusion is often unnecessary. Every element of the hip is available adequately for treatment with tools. Because the acetabulum forms the floor of the wound, reamers can be applied with great mechanical efficiency. These matters possibly are of little importance to the surgeon who approaches the hip joint with the meticulous care of a Smith-Petersen. Are there still other advantages?—It seems that there may well be. Certainly, by the Kocher approach one can avoid the denudation of the gluteal surface of the ilium, the disturbance of the abdominal muscles and the harsh retraction of the hip flexor muscles. The less we interfere with muscles the better, for the greatest difficulty in the rehabilitation of patients following arthroplasty of the hip is the restoration of muscular competence. And here is a further feature in the posterior approach: the insertions of the deep gluteal muscles can be given greater mechanical advantage by transplantation to a lower level upon the femur. Though Gibson does not mention it, both the approach and this reattachment are facilitated by osteotomy through the base of the great trochanter: a feature well demonstrated by Charles Gray in his excellent moving picture shown at the meeting of the British Orthopaedic Association at Bristol in October 1949.

In practice one finds that the incision is much more nearly a vertical curve than is suggested by the illustrations in Gibson's paper. Obviously nothing new has been presented; nevertheless, it is good that interest should be revived in a neglected method of such real value for the many operative procedures commonly performed upon the hip joint. The method goes a long way to support the author's view that it is *facile princeps*.

NORMAN CAPENER.

OBLIQUE DISPLACEMENT OSTEOTOMY FOR OSTEOARTHRITIS OF THE HIP JOINT

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and
W. H. Fahrni, Vancouver, Canada

From the Department of Orthopaedic Surgery, University of Liverpool

Bifurcation or oblique displacement osteotomy of the femur in the treatment of osteoarthritis of the hip was first recommended by Lorenz (1925). The operation was described by Galland (1930) and later developed in Britain by McMurray (1935, 1939). In this paper is presented a study of certain theoretical and practical aspects of the operation based on anatomical dissection, experimental evidence, and on a review of the late results.

Although the etiology of osteoarthritis is uncertain, we accepted the conclusions of Bennett, Waine and Bauer (1942) who stated: "Regardless of etiology, two fundamental considerations apply to every example of degenerative joint disease. One is the disadvantageous biological position of articular cartilage when subjected to injury. This is evident anatomically in the paucity of its cellular constituents and remoteness from blood supply and physiologically in its low respiratory rate and extremely limited faculty of autogenous repair. The other concerns the effect of mechanical stress and strain incident to joint function upon a tissue whose specific means of resistance to such use has been depleted." On this basis the physiological reaction of hyaline cartilage to normal stresses is an essential factor in the osteoarthritic process and by governing those stresses it should be possible to control the reaction. We therefore studied the mechanics of the hip joint to see how much of the relief afforded by the osteotomy is due to alteration of local stresses in such a way as to diminish the wear and tear on the articular surface of the head of the femur and the acetabulum.

THE MECHANICS OF THE HIP JOINT

It may not have been fully appreciated that the force acting on the head of the femur is not simply the weight of the body. Gickler and Beining (1935) and Inman (1947) have demonstrated that the hip joint acts on a lever principle (Fig. 1), the weight of the body at one end of the lever being counterbalanced by the pull of the abductor or anti-gravity muscles at the other end. The head of the femur, being the fulcrum, is subjected to a summation of these forces, amounting to at least double the body-weight according to Inman.

Since we believed that this load was further increased on the deformed arthritic hip, the following experiment applying the lever principle was performed. A hip joint was dissected out and set up as in Figure 2. In the joint was placed a fluid-filled bulb which conformed perfectly to the concave shape of the acetabulum and was allowed to invaginate sufficiently to accommodate the head of the femur. The pressure in the joint was measured by a constant volume pressure gauge of the diaphragm type which was connected to the bulb. The action of the two forces to be studied—gluteal power and body-weight—was reproduced by weighted strings attached to the pelvis, as in Figure 2, and the precise anatomical direction in which each force acted was determined.

Determination of the line of gluteal pull—Reference to Figure 1 shows that the body-weight is the force acting on one end of a lever the fulcrum of which is at the hip joint. The effort on the other end of the lever is provided by the anti-gravity muscles, consisting of the three glutei, tensor fasciae latae and possibly the pyriformis. As a group these muscles have their

origin in an oval area on the ilium and sacrum, and thence they converge downwards and laterally, at an angle of about 45 degrees, in the shape of a rather flattened cone to the region of the great trochanter. It is possible to resolve the action of this group into a single line of force with reasonable accuracy by drawing a line from the tip of the great trochanter to the mid-point of a line joining the antero-superior spine to the most posterior attachment of the glutei on the sacrum (Fig. 3). This gives the first line of force; its position corresponds very closely with the resultant of the action of the abductors as a group as deduced by Inman.

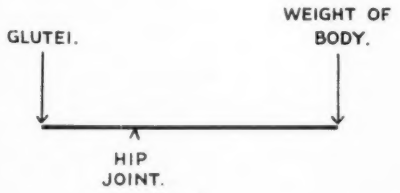


FIG. 1

The lever principle of the hip joint. The joint acts as the fulcrum of a lever, the long arm of which supports the body-weight; the short arm is controlled by the gluteal muscles.

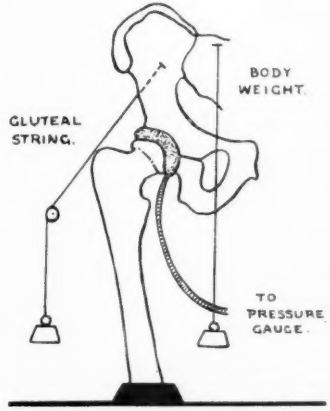


FIG. 2

Construction of the experiment (see text).

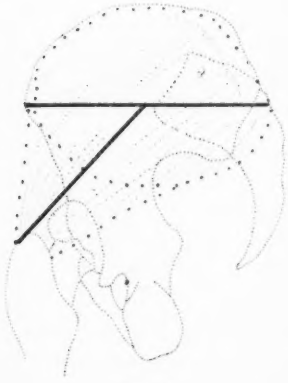


FIG. 3

Postero-lateral aspect of the hip, showing attachment of the glutei and resultant line of force of hip abductors.

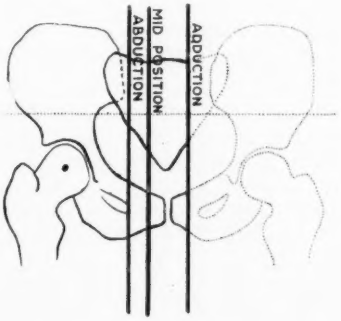


FIG. 4

Position of the line of body-weight.

Determination of the line of weight-bearing—We have been unable to find reference in the literature to any method of localising accurately the line of body-weight. Calvé (1939) in his discussion of the coxalgic gait stated that it lies slightly medial to the hip joint. Ponseti (1946) stated: "Normally the hip joint is considerably separated from the line of gravity and consequently forces of gravity create a rotary effect on its centre of motion." Inman (1947) claimed that the centre of gravity necessarily lies in the medial sagittal plane.

There can be no doubt that the centre of gravity passes through or slightly in front of

the middle of the ankle joint when the subject is balanced on one foot in the neutral position. If a radio-opaque plumb-line is dropped through this point on the ankle and an antero-posterior radiograph of the pelvis is taken with the beam centred on the plumb-line, it must indicate the position of the line of body-weight relative to the pelvis. This was done in the positions of full active abduction, mid-position and adduction of the hip, and the results are shown in Figure 4. We have ascertained the position of this line in a patient with severe adduction deformity associated with an uncompensated scoliosis and found that it lies even farther out than the extreme limit for normal adduction as indicated in the diagram.

Having now determined the line along which each force acts, we can proceed with the experiment. For each position of the hip certain body-weights were applied and balanced with the appropriate weight on the "gluteal" string. The readings of the joint pressure gauge were recorded. The experiment was then repeated using a femur on which an oblique displacement osteotomy had been performed.

Results—Table I shows the force to which the head of the femur is subjected in the normal hip and after displacement osteotomy. Note the high reading in the adducted position; this would be constant in the deformed arthritic hip. In such a patient weighing 150 lb. it can be calculated that the force passing through the joint will be approximately 450 lb. during walking. This load must be responsible for the unrelenting progress of osteoarthritis in a hip that has entered into the stage of deformity. Any procedure that corrects the adduction deformity therefore will diminish the increased load and this fact probably accounts for the success of simple corrective osteotomies without displacement, as advocated by Hey Groves (1933) and Malkin (1936). As some adduction movement is still retained, however, adduction deformity can recur and will be followed by an increased strain on the hip.

After displacement osteotomy (Table I) the third column shows a zero reading, indicating a complete absence of weight-bearing strain through the hip joint. The adjoining diagrams show a reversal of the mechanical disadvantage due to shifting the weight-bearing fulcrum medially towards the line of body-weight. With transference of the point of weight-bearing to the pelvis, the gluteal power necessary to balance the body-weight is no more than one quarter of that required in the normal state. Whether this ideal mechanical effect is ever gained clinically is uncertain.

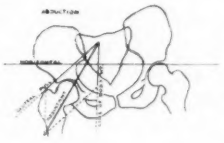
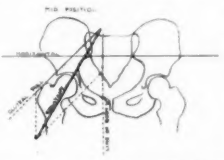
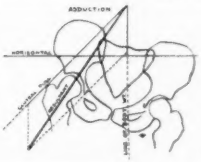
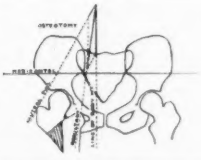
Position of the distal fragment—The above experiment was carried out on the assumption that after displacement osteotomy the distal fragment of the femur lay in contact with the pelvis in such a manner that weight was borne through it. Direct evidence of this by post mortem examination of old osteotomy cases was not available. The position of the distal fragment was, however, investigated: 1) by taking stereoscopic radiographs of the pelvis after osteotomy; and 2) by carrying out the operation in cadavera, checking the position by radiography to see that adequate displacement had been obtained and then dissecting away the overlying soft tissues to display the bony relationships. Both these methods showed that the inner angle of the distal fragment was displaced into the obturator externus and that its upper surface lay in contact with the under surface of the transverse ligament of the acetabulum. The lesser trochanter lay against the inferior ramus of the ischium which limited its displacement posteriorly. This position of the lower fragment in such close proximity to the hip inevitably tends to limit movement of the joint, adduction and extension being absent and rotation grossly diminished.

CLINICAL STUDY

Theoretical considerations, as outlined, suggest that the beneficial effect of displacement osteotomy in osteoarthritis of the hip is due firstly to correction of deformity and secondly to the bone block effect of the displaced shaft which prevents the further development of the adducted position and may act as a pelvic support. The end-results of a series of seventy-five cases treated by this operation have been reviewed and the principal features are summarised

TABLE I

JOINT PRESSURE FOR GIVEN BODY-WEIGHT

Position of hip	Body-weight (*lb.*)	Normal hip: Gluteal pull (*lb.*)	Joint pressure* (*lb.*)	Diagrams to show forces acting through hip joint
Abduction	10	11	19	
	20	24	41	
	30	37	61	
Mid-position	10	17	25	
	20	33	49	
	30	47	71	
Adduction	10	21	38	
	20	47	62	
	30	70	94	
After displacement osteotomy	10	4	0	
	20	7	0	
	30	12	0	

*Pressure gauge readings have been corrected from pounds per square inch to total pounds passing through the joint.

in the following paragraphs. Clinical study of this material seems to confirm the accuracy of the above hypothesis.

Pre-operative condition. *Age incidence*—Fifty patients (66⅔ per cent.) were between the ages of forty-five and sixty-five years. Thirteen patients were under forty-five; seven over sixty-five. The youngest patient was twenty-three and the oldest seventy-four. *Sex*—There were nineteen males and fifty-six females. *Signs and symptoms*—In all the cases reviewed the arthritis was unilateral or predominantly so at the time of operation. *Pain* of a severe nature had been present from one to five years in 65 per cent.; for five to ten years in 25 per cent.; and for more than ten years in 10 per cent. *Disability*—This reflects the severity of the pain and was assessed in three categories: 1) ability to continue work although with difficulty, and to walk one mile (40 per cent.); 2) ability to do limited work, but not to walk one mile (40 per cent.); 3) marked incapacity, usually confined indoors (20 per cent.). *Movements* were markedly limited in all cases. Flexion was less than 10 degrees in 20 per cent.; 10 to 60 degrees in 50 per cent.; and 60 to 90 degrees in 30 per cent. Rotation and

abduction were always grossly restricted. *Deformity*—some degree of flexion, adduction and lateral rotation deformity was present in most cases.

PRINCIPLES AND TECHNIQUE OF THE OPERATION

The operation consists of a high oblique trochanteric osteotomy with displacement of the distal fragment against the side of the pelvis. It is based on the operation described by Lorenz for congenital dislocation of the hip; although the main features of oblique section of the femur and displacement are present, the adaption of the Lorenz operation to the osteoarthritic hip has necessitated many essential changes in technique and management. Ideally the post-operative radiograph should show the Y or bifurcation appearance (Fig. 5) and all such cases in this series have gained a good and lasting result. In detail, the distal fragment should be displaced below the inferior acetabular rim, and the proximal fragment should lie adducted so that apposition of the two fragments is maximal and union correspondingly rapid. In the attainment of this optimal position and the achievement of a subsequent beneficial effect, certain features of the initial stage, operative technique and after-care are of significance.

Pre-operative factors—In osteoarthritis of the hip the inferior half of the acetabulum often shows hypertrophic changes (Fig. 6), with the formation of a curved plate of bone lying between the lower part of the head and the normal acetabular floor, and extending inferiorly as a broad osteophyte. This secondary floor becomes increasingly prominent as subluxation progresses. Its presence is a favourable feature, because, after osteotomy, the displaced femoral shaft will abut against this mass of bone. In many cases support of the pelvis is successfully achieved in this way.

If an oblique osteotomy is undertaken in the presence of a mobile hip, abduction of the upper fragment may occur, owing to contraction of the glutei. The consequent loss of apposition of the divided bone surfaces entails risk of non-union or gross deformity. However, in cases in which operation is called for, abduction is usually absent or markedly limited and so this complication cannot occur. Patients with minimal joint changes and a relatively free range of abduction should not be submitted to this operation. When, as is usually the case, adduction deformity is present, the neck and shaft of the femur lie nearer to the pelvis than normally. If osteotomy is now performed at the correct level the degree of displacement required is less than that which would be necessary in a hip without deformity. Considerable apposition of the fragments remains and union is rapid. Good bone contact is occasionally maintained in cases that have no adduction deformity, for, as displacement occurs, the upper fragment—impelled by an intact posterior link of soft tissues—may follow the lower and assume a position of adduction. Unfortunately, this change of position does not often happen.

When lateral rotation deformity is present the shaft of the femur lies in a more posterior plane than normally. Nevertheless the osteotomy should always be performed from the lateral aspect of the shaft, and the rotation deformity should be corrected after the lower fragment has been displaced. The effect is to open the two osteotomy surfaces like a hinge and to diminish the area of apposition. Some delay in union has occasionally occurred from this cause, but consolidation has always been achieved by prolonging the period of immobilisation. Gross lateral rotation deformity, therefore, is not considered a contra-indication to operation.

If a severe flexion deformity is present the intertrochanteric region of the femur is situated on a plane anterior to the acetabulum. In such a case the distal fragment of the osteotomy when extended is liable to be displaced forwards into the adductor muscle mass instead of below the hip joint. In this situation the fragment is held forward by the contracted psoas muscle, which subsequently may pull it upwards in front of the neck of the femur. The result is a failure of the operation, gross shortening of the leg and often a painful pseudarthrosis. In order to avoid this complication a flexion deformity of more than 35 degrees should be overcome

FIG. 5

Typical Y-shaped appearance of the upper end of the femur after displacement osteotomy.

FIG. 6

Advanced osteoarthritis of the hip joint, showing hypertrophic bone formation in the floor of the acetabulum.

FIG. 7

Spike from medial margin of femoral neck preventing adequate displacement of the distal fragment after osteotomy.

by pre-operative traction; if smaller it can often be corrected by manipulation immediately before osteotomy. When, in spite of these measures, obvious deformity still persists, an oblique osteotomy should not be undertaken.

Operative technique—The operative technique can best be described in the words of McMurray (1939): "The femur is approached through a six-inch vertical incision on the outer side of the upper portion of the shaft. After the muscle attachments have been stripped from the front of the shaft and the neck of the femur, so that the exact relationship may be appreciated, the bone is divided in an oblique line at an angle of 40 degrees, so planned that the upper end of the osteotomy lies between the lesser trochanter and the neck of the femur. The osteotomy must be complete, so that splintering does not occur. After the two fragments are separated, the lower fragment is displaced inward until its upper margin lies directly under the cotyloid ligament of the hip joint. If this displacement is not sufficient there can at best be only a partial relief of symptoms and a disappointing result. At first, a gap is left between the divided surfaces of the two fragments, but gradually this space becomes obliterated by the rotation inwards of the lower end of the upper fragment, which is pulled in this direction by the muscles which have a common attachment to both fragments. The fracture is then treated by fixation of the hip, thigh and leg in a long plaster-of-Paris spica, with the limb in 20 degrees of abduction, and with the knee and hip flexed to 25 degrees, thereby preventing any strain on either joint. This position of abduction is retained for two and a half weeks. The cast is then removed, the stitches taken out and a new plaster spica is applied, this time with the limb in the neutral position and the hip and knee again in slight flexion."

Good access to the medial border of the neck of the femur is essential, and the key to this is the accurate insertion of a bone lever above the lesser trochanter between the psoas tendon and the bone. The posterior lever should be placed below the level of the lesser trochanter and no attempt should be made to strip the muscles from the posterior aspect of the osteotomy site. This leaves soft tissue continuity between the two fragments which helps to maintain apposition during displacement.

The precise line of the osteotomy should first be marked out on the front of the bone by a series of linear cuts extending through the anterior cortex and half-way across the shaft of the bone. The most medial chisel cut at this stage divides the dense compact bone on the medial border of the base of the neck. Neglect of this step may lead to longitudinal splintering of the neck when the osteotomy is completed from the lateral side, and so cause separation of the inner border of the neck as a longitudinal spike which remains attached to the distal fragment and often acts as an obstacle to displacement (Fig. 7).

The best angle of division has been found to be about 40 degrees with the transverse plane. If it is less, difficulty in displacement may be encountered because the lateral corner of the distal fragment impacts against the inferior cut surface of the proximal fragment, limiting the abduction movement on which maximal displacement depends. If the obliquity is more than 40 degrees, the osteotomy line is long and may encroach on the lower border of the neck where dense capsular attachment is a hindrance to displacement. The correct level for division of the shaft is such that after displacement the lower fragment lies just below the acetabulum. This level can usually be achieved by ensuring that the inner angle lies between the lesser trochanter and the base of the femoral neck. If the femur is markedly subluxated upwards, or the inferior margin of the acetabulum is hypertrophied downwards to such an extent that attainment of the desired position after displacement seems impossible, no correction of level should be attempted for the following reasons: 1) If the femur is divided through the lesser trochanter adequate displacement is prevented by the insertion of the psoas tendon; osteotomy below this level leads to difficulty in controlling the position in plaster. 2) Simple displacement of the distal fragment against, instead of under, the secondary acetabular floor still provides adequate pelvic support, although it tends to limit hip-joint movement.

Post-operative treatment—Abduction is an integral part of the displacement manoeuvre and it is important that it be maintained in the initial post-operative period (Fig. 8). Abduction at this stage renders the fragment stable in its new situation by impacting it against the pelvis medially and the upper fragment above, and an angle of up to 45 degrees may be necessary. It has been found that flexion is also essential to discourage forward riding of the shaft in front of the neck. This flexed and abducted position is maintained for two and a half weeks, when the early stages of union are sufficiently advanced to prevent the displaced fragment from slipping from its new site. When the second plaster is applied the leg is restored to the mid-position (Fig. 9), the flexion and abduction being corrected simultaneously. The manoeuvre of converting the abducted to the neutral position can be carried out to the best advantage at this stage when the adhesive property of the early callus allows controlled movement of the fracture without jeopardising position. The axis of movement is at the osteotomy site and as the mid-position is approached the inner angle of the displaced fragment comes to lie more intimately against the pelvis. The two essential features of pelvic support and optimal functional position are thus achieved (Fig. 10) without resort to mathematical calculations or complex radiological techniques. While we agree with Milch (1947) that an excessive post-osteotomy angle will result in permanent abduction deformity and gross limitation of hip movement, this problem does not arise if the above procedure is carried out.

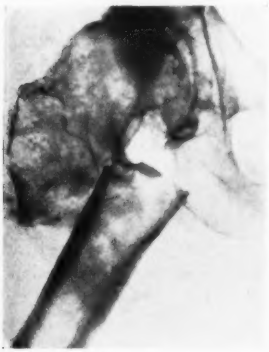


FIG. 8

FIG. 9

FIG. 10

In the early post-operative period abduction of the distal fragment (Fig. 8) helps to maintain adequate displacement. Two to three weeks after operation the alignment is changed to the neutral position (Fig. 9). Figure 10 shows the condition two years later. Note that the displaced shaft lies snugly under the rim of the acetabulum.

Union of the osteotomy usually occurs within three and a half months. The second plaster is then removed and the patient allowed weight-bearing exercises. Supervision in hospital is desirable for about two weeks, after which the patient may be allowed to go home, walking with two sticks. Slow but steady improvement takes place during the subsequent six to nine months.

RESULTS

Ninety-three operations were performed with three deaths. Seventy-five cases have been followed and sixty-eight of these have been seen and examined personally by us. The intervals between operation and review were as follows: over one year, seventy-five cases; over three years, forty-five; over five years, thirty-one; over ten years, eleven; over twelve years, one case. *Pain*, the primary indication for operation, was the main criterion for assessing results. It was relieved in sixty-one cases (81 per cent.), not relieved in fourteen cases (19 per cent.). *Shortening*—The average shortening originally due to the osteoarthritis was one-third

of an inch. After operation the average shortening was just less than one inch. *Movement: Adduction*—In fifty-eight (95 per cent.) of the successful cases a solid check to adduction movement was encountered at or about the neutral position. This was caused by impingement of the distal fragment against the pelvis and was good clinical evidence of a pelvic support mechanism. *Flexion*—On the basis of this movement a further sub-division of the successful cases was made into three groups: *Group A*—47 per cent. of the pain-free patients regained between 10 and 60 degrees of active flexion. The degree of limitation of flexion was roughly proportional to the degree of osteoarthritis as demonstrated radiographically and bore no relation to the pre-operative range of movement. Patients in this group walked with a satisfactory, if somewhat ungainly, gait. They had no signs of hip instability, as the pelvis was supported solidly against the displaced femoral shaft. They were not able to take a normal stride because, on bearing weight, extension of the hip was impeded by impingement of the femur against the pelvis. As soon as weight was taken on the other leg, however, the hip was free and could be swung forward for the next step. This check to antero-posterior movement of the hip was reflected in a slight shortening of the pace—a characteristic feature of the " osteotomy " gait. A list to the affected side at each step was also seen. This was due to the necessity for the spinal column to compensate fully for the transference of body-weight from one leg to the other instead of sharing it with an actively abducting hip. *Group B*—In 30 per cent. there was hip flexion of less than 10 degrees. These patients walked with the well-known gait associated with ankylosis of the hip; and a few complained of backache, attributable to the increased movement demanded of an osteoarthritic lumbar spine. Gross limitation of movement was due to the following causes: 1) Previous operative interference such as a failed arthrodesis or arthroplasty. 2) Severe osteoarthritis with complete loss of joint space secondary to traumatic or infective arthritis. 3) High osteotomy, with inadequate displacement, the distal fragment lying directly under the femoral head and impinging against the hypertrophic bone in the floor of the acetabulum. *Group C*—In 23 per cent. of the successful cases there was active hip flexion of more than 60 degrees; the greatest range was 120 degrees. These patients showed the best that can be expected from this operation. They walked with an almost normal gait; they had up to 30 degrees of abduction movement with active control of the gluteal muscles. They had little or no disability and would compare favourably with the best results of any other operation.

Late functional results—After this operation the average improvement is such that considerable diminution in general disability results. The housewife can continue to look after her own home, and most patients are able to earn their living. They have returned to work on the docks, on farms, and as industrial labourers. Young people are able to dance, ride a bicycle and walk several miles without fatigue. A minority rely upon the support of a stick when walking outdoors and most patients are able to negotiate stairs with ease. A restriction inherent in the limited movement of the average case is the difficulty in fastening the shoe on the affected side. The almost constant relief of pain is the main benefit that can be promised. The final range of movement cannot be predicted and although in this series the average range of flexion was 45 degrees a marked variation occurs in individual cases as compared with the pre-operative range. When radiographs show gross loss of joint space without subluxation, or a mass of encircling osteophytes, post-operative stiffness tends to be severe; but the final range probably depends on the amount of fibrous tissue formed between the displaced fragment and the lower border of the acetabulum.

Radiographic features—No clinically successful case reviewed here has shown radiographic evidence of progress of the arthritis. There have in fact been many examples of partial restoration of joint space. The articular surfaces have become more clearly defined and regular in outline (Figs. 11 to 14). Radiographic evidence of impingement of the distal fragment against the pelvis is often apparent (Fig. 15). This has been confirmed in several cases by stereoscopic radiography.

FIG. 11

FIG. 12

Case 1. Figure 11 shows gross narrowing of the joint space three months after operation. Three years later the radiograph showed well-marked restoration of the joint space and improved definition of the joint outline (Fig. 12).

FIG. 13

FIG. 14

Case 2. Figure 13 shows condition of hip two months after displacement osteotomy. Figure 14, radiographic appearance four years later.

Mortality—Three patients out of the total of ninety-one died within three months of the operation. One death was due to an infected haematoma and septicaemia. The other two were due to cardiac failure and uraemia.

COMPLICATIONS

Limitation of knee movement—A criticism of the operation has been that in the older patients stiffness of the knee occurs because of the necessary period of immobilisation in plaster. In this series the pre-operative range of knee movement was regained within six months in all except six cases. The rapidity of recovery seemed to vary inversely with the degree of degenerative arthritis present in the joint. *Knock-knee*—This is occasionally apparent after any upper femoral osteotomy in which the shaft of the femur approaches the mechanical axis. It is seen to its greatest degree in females with short legs and a wide pelvis. *Non-union* was observed in three patients—in two cases despite adequate displacement. One of these (Fig. 16) had no pain eight years after operation; he was able to walk five miles and at the age of sixty-five years was still working as a dock foreman. Another patient, aged seventy-two years, had an unstable hip but with the use of a stick was able to walk for one mile without pain. In the third case immobilisation was inadequate owing to extreme obesity and full displacement was not maintained. She had less pain than before the operation but had a marked limp and was unable to walk more than half a mile. Non-union due to forward riding of the lower fragment as a result of performing the operation in the presence of excessive flexion deformity has been observed elsewhere but has not occurred in this series.

Persistent pain—In fourteen patients pain was not relieved by the operation. Two of these patients were communicated with by letter; the remaining twelve attended for examination. Without exception they showed absence of the block to adduction movement which is the index of pelvic support and the criterion of a successful mechanical result. Radiographic examination confirmed that adequate displacement had not been achieved (Fig. 17). In seven cases the failure to secure adequate displacement was explained easily from among four causes: 1) local fibrosis due to previous operations—three cases; 2) a long inner spike on the distal fragment due to splintering of the neck—two cases; 3) calcification in the psoas tendon—one case; and 4) extreme obesity causing inadequate immobilisation with slipping back of the distal fragment—one case. In the other five cases no reason for the technical failure was evident.

It has been indicated that three patients, who at the time of review were placed in the successful group, also failed to show either a block to adduction or radiologically adequate displacement. This apparent anomaly is explained by an analysis of twenty available cases in which displacement was inadequate (Table II). This suggests that correction of deformity

TABLE II

ANALYSIS OF TWENTY CASES OF FEMORAL OSTEOTOMY IN WHICH DISPLACEMENT WAS INADEQUATE

Years since operation	Results	
	Good	Bad
2	6	2
4	2	4
over 4	0	6

(Malkin 1936) and a prolonged rest in plaster, with subsequent curtailment of activity for a further six to twelve months during the rehabilitation period, are sufficient to bring about a temporary improvement in the condition of the hip joint which may give the patient relief from symptoms for as much as four years. Nevertheless the absence of any weight-relieving mechanism

FIG. 15

Nine years after oblique osteotomy, showing site of impingement of the displaced fragment.

FIG. 16

Non-union after osteotomy. Displacement has been adequate and the functional result is satisfactory.

FIG. 17

Inadequate displacement after osteotomy. The hip is unstable and disabling symptoms persist.

for the hip joint, such as is afforded by the displacement osteotomy, puts a time limit on the period of relief and eventually the degenerative process is reactivated with its attendant pain. In two such cases in this series the operation has been repeated correctly, and with success.

SUMMARY

1. Experimental evidence is advanced to suggest that the effect of the McMurray displacement osteotomy in osteoarthritis of the hip is to diminish the load carried by the head of the femur, firstly by correction of deformity, and secondly by a " pelvic support " action.

2. A review of seventy-five cases has revealed certain important details in selection and operative management. The end-results indicate that the operation, when correctly performed, is successful in relieving pain and diminishing disability.

We wish to acknowledge our indebtedness to Mr Goronwy Thomas, Mr Bryan McFarland and, most particularly, to the late Professor T. P. McMurray for all the help and encouragement we received.

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PSEUDARTHROSIS OF THE HIP JOINT

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The problem of disabling osteoarthritis of the hip is difficult when only one hip is involved, far more so when both are affected. The orthopaedic surgeon is largely concerned with the improvement of function, and with operations of choice rather than of necessity; but in cases of severe osteoarthritis of the hip, with its progressive interference in work, recreation and sleep, any relief that he can give by operation becomes a matter of necessity. The operations available include arthrodesis, arthroplasty, pseudarthrosis, osteotomy (McMurray 1935) and denervation of the joint (Tavernier and Godinot 1945). It is the object of this article to describe one of these methods—pseudarthrosis—and to report on the long-term results. It is well that every surgeon should appreciate the facts about each of these operations—its magnitude, reliability, capacity to restore activity and function of the hip, its demands upon other joints (particularly those of the lumbar spine) and the duration of the relief that can be expected.

In the past, the operation most frequently employed for the relief of osteoarthritis of the hip has been arthrodesis. This is often successful in relieving pain and securing stability at the expense of movement. But the hip was designed to move; and movement in or near the hip is desirable for both sitting and walking. When the hip is fused, excessive strain is thrown on the lumbar spine, which in elderly persons is frequently itself the site of degenerative changes. Cup arthroplasty of the hip joint, a severe operation designed to restore movement and preserve stability, is still under trial. It is possible that further advances may place it in the category of reliable operations with lasting benefit, but evidence is, as yet, incomplete. Osteotomy of the type advocated by McMurray (1935) relieves pain in selected cases but is by no means applicable to all. Prolonged post-operative plaster immobilisation is necessary but is not borne well by older patients. Cordotomy is a grave and uncertain expedient. Manipulation seldom relieves pain. Tavernier and Godinot (1945) claim success for denervation but confirmation is still lacking. The injection method of Waugh (1945) is only occasionally effective.

The operation of pseudarthrosis, as first performed by Girdlestone in 1923, was a modification of the method advocated by Sir Robert Jones (1921) for ankylosis of the hip joint, in which the greater trochanter with its attached muscles was attached to the stump of the femoral neck after excision of the head. The term *pseudarthrosis of the hip joint* implies in this paper excision of the head and neck of the femur and trimming of the acetabular rim. The advantages claimed are: 1) that it relieves pain; 2) that it corrects deformity; 3) that it restores free movement; and 4) that the benefit gained is permanent. Moreover, a remarkable degree of stability is preserved.

TECHNIQUE OF OPERATION

The approach employed is that originally described by Smith-Petersen (1936). This has the advantage of preserving the important medial rotator muscles—the tensor fasciae latae and the anterior fibres of the gluteus medius—with their nerve supply. The branches of the lateral femoral circumflex artery are caught before division and ligated. In extending the deep incision backwards round the crest of the ilium a sufficient margin of fascia is left to facilitate reattachment of the muscles. The joint capsule with its synovial lining is removed

in front, above and below. With a broad gouge the anterior and upper rim of the acetabulum is removed. The gouge enters the bone half an inch above the upper margin of the acetabulum and is directed to reach the socket an inch or so inside. This is an important technical detail which permits easy dislocation of the head of the femur from the acetabulum and minimises the shock that is often associated with forcible dislocation. Rotation of the limb is controlled by an assistant who turns the head and neck of the femur out of the wound. The neck is divided at its distal end, preferably with a hand-saw or a Gigli saw, and the head and neck are removed (Fig. 1). Sharp edges of bone are smoothed with a nibbling forceps or fine chisel. The wound is closed, steady traction on the limb being maintained by an assistant.

FIG. 1

Typical radiographic appearances after pseudarthrosis. The head and neck of the femur have been excised completely and the prominent rim of the acetabulum has been bevelled off.

Post-operative management—The limb is suspended from a suitable beam in a Thomas's splint with Pearson knee-flexion attachment, the knee resting in about 30 degrees flexion. Traction is maintained throughout the period of splintage; it must be sufficient to preserve normal length. The patient lies flat at night to prevent flexion deformity, but sits up freely during the day. It is important that lateral rotation be avoided; the limb should rest in the neutral position. Two weeks after operation, quadriceps exercises with assisted active flexion and extension of the limb are begun. The Thomas's splint is retained for four weeks, after which it is replaced by Russell traction, using pulleys as advocated by Dommisse and Nangle (1947). This allows for massage and for graduated active and passive exercise

of the hip and knee. After eight weeks the patient is encouraged to stand on the sound leg; a week later he walks in a bucket-top caliper with crutches, and after a further week two sticks are substituted for the crutches. Ultimately he learns to walk with the aid of one stick held in the opposite hand. He is advised to wear the caliper constantly during the day for the first six months and afterwards for all active pursuits. It should be regarded as a friendly and helpful tool designed to give greater activity and to spare the limb from strain and undue shortening. The importance of efficient post-operative treatment cannot be over-emphasized. Without it the most technically brilliant operation may be useless.

RESULTS

Ninety-three patients have been reviewed. The average age at the time of operation was fifty-five years; the oldest was seventy-five years and the youngest twenty years. Thirty-nine patients were men and fifty-four women. The indications for operation are shown in Table I.

TABLE I

CLASSIFICATION OF PRIMARY DISEASE IN NINETY-THREE PATIENTS TREATED BY PSEUDARTHROSIS

Osteoarthritis:	
Unilateral	59
Bilateral	14
Ankylosing spondylitis	11
Rheumatoid arthritis	1
Septic arthritis	1
Ununited fracture of femoral neck	5
Unreduced fracture-dislocation	1
Tuberculous arthritis	1

Patients classed as having good results gained complete relief from pain and were able to walk well with the aid of a stick. About 30 degrees of active flexion was regained. Passively, there was flexion to 80 degrees, abduction and adduction to 30 degrees, medial rotation to 10 degrees and lateral rotation to 30 degrees. The average shortening of the limb was one and a half inches. The result was classed as good in eighty-three cases and poor in seven cases. Three patients died as a result of the operation.

In cases of bilateral osteoarthritis six patients whose more painful hip had been operated on gained satisfactory relief and were able to walk with the aid of two sticks or crutches. Five patients whose opposite hip had previously undergone arthrodesis walked with the aid of two sticks; it is noteworthy that of these five, two later developed stress fractures in the subtrochanteric region on the side of the fusion. One required abduction osteotomy, but both are now walking well with the aid of two sticks. Although the results are less satisfactory in bilateral disease the relief that can be gained—if only in one hip—is nevertheless sufficient to make the operation well worth while. The best results so far obtained in bilateral osteoarthritis are those in which arthrodesis was performed on one side and pseudarthrosis on the other.

Unreduced fracture-dislocation of the hip joint—The single patient in this category gained an excellent result. The operation was performed at the age of twenty-six years. Six years later she stands and walks well without pain, and there is active hip flexion of 80 degrees.

Tuberculosis—One patient with tuberculosis of the hip was operated upon. There is no sign of reactivation four years later. She walks well with a stick; she is able to climb stairs and to walk short distances without a stick. The hip is painless, but there is a shortening of one and a half inches. Pseudarthrosis in this case was an alternative to amputation; the destruction was so extensive as to make arthrodesis impracticable.

Septic arthritis—The first patient in this series, submitted to operation in 1923 for septic

arthritis, is able to walk quite long distances even at his present age of seventy-eight years.
Rheumatoid arthritis—Only one patient has been operated upon. The result was unsatisfactory owing to the polyarticular nature of the disease. Pseudarthrosis is probably not advisable in this disease.
Ununited fractures of the femoral neck—Pseudarthrosis has been employed in cases of non-union as well as in those in which union has occurred but degenerative arthritis has supervened. It has also been used when degenerative arthritis has followed osteotomy performed to obtain union of the femoral neck. Avascular necrosis in the femoral head is usually responsible for complications of this kind. The results in cases of non-union, as in cases of osteoarthritis, were good.

FIG. 2
In this case of ankylosing spondylitis a satisfactory range of movement at both hips has been regained after bilateral pseudarthrosis.

Ankylosing spondylitis—Eleven cases have been reviewed—seven after unilateral pseudarthrosis and four after bilateral pseudarthrosis. With one exception the results were satisfactory. In the ten successful cases the patient was able to walk reasonably well with two sticks and to sit with comfort. Passive flexion at the hip level averaged 70 to 80 degrees; and there was adequate stability. In this distressing disease skeletal rigidity may extend from the skull to the ankles. In these circumstances movement at one or both hips is essential if the patient is to walk or sit. One case in the series was of this type. After bilateral pseudarthrosis he is able to walk with the aid of two sticks and has regained 50 to 60 degrees of movement at both hips six years after operation (Fig. 2). Another patient has a good range of well-controlled movement in the pseudarthrosis twenty years after unilateral operation. In the light of more recent work bilateral pseudarthrosis is recommended in this disease. Moreover, a raised sedimentation rate is not regarded as a contra-indication to operation; in one case with persistent severe pain in the hip, operation was performed in the presence of a sedimentation rate as high as 120 millimetres in one hour (Westergren).
Comment on poor results—Seven poor results were recorded. One patient with rheumatoid arthritis, although relieved of pain in the hip, was subsequently unable to walk well because of involvement of other joints. In two cases a spur developed on the femoral stump which impinged against the acetabulum—a complication that would have been avoided by careful bevelling. Operative remodelling of the surfaces is advised in these circumstances. Two patients with bilateral osteoarthritis, who had arthrodesis of one hip and pseudarthrosis on

the other, subsequently developed stress fracture of the subtrochanteric region on the side of arthrodesis. In each case satisfactory union was secured, and both patients are able to walk with the aid of sticks. In one of the earlier cases the head of the femur was left in the acetabulum; this led to ankylosis. Strict adherence to standard operative technique would have prevented such a result. One patient so obese that post-operative management was difficult—and satisfactory fitting of a caliper impossible—had a residual lateral rotation deformity and poor function. Adequate post-operative traction through a Steinmann's pin would probably have prevented this. Another patient classed as having a poor result was a man of fifty-seven who was disappointed in not being able to play games after the operation, although he was able to walk with the aid of sticks and was relieved of pain. It is felt that the scope and nature of this operation is to relieve pain and to restore mobility and limited function. It does not restore normality.

SUMMARY

1. The operation of pseudarthrosis of the hip joint is described and the results are assessed in ninety-three patients.

2. The result was good in eighty-three cases and poor in seven cases. Three patients died as a result of the operation.

3. Pseudarthrosis is the most satisfactory and the most reliable operation: 1) in ankylosing spondylitis, and 2) in patients over sixty years of age with disabling osteoarthritis.

4. The more formidable operation of cup arthoplasty may prove to be superior in younger patients with osteoarthritis.

I am indebted to Mr G. R. Girdlestone, Mr W. B. Foley, Mr J. C. Scott and Professor J. Trueta for permission to investigate their case records, and for advice and criticism in the preparation of this paper: and to Dr F. H. Kemp of the Radiological Department. I also wish to thank members of the photographic and secretarial staff of the Wingfield-Morris Orthopaedic Hospital for their help.

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THE USE OF AN ARTIFICIAL FEMORAL HEAD FOR ARTHROPLASTY OF THE HIP JOINT

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The purpose of this article is to describe a special procedure for arthroplasty of the hip. The idea of the operation, which we have called "resection-reconstruction," is excision of the pathological femoral head and its replacement by an artificial head, made of a synthetic plastic material, which is firmly fixed to the upper end of the femur. This study is based on 300 cases, the earliest of which dates back some three and a half years.

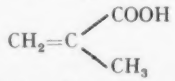
In France, up to the present time, arthroplasty of the hip has been practised mainly according to Whitman's (1924) technique (Fig. 1). Professor Mathieu in particular has taught and perfected this operation, but a review of the late results shows that out of every five cases, only one is good, one is fair, and three are poor. For a result to count as good, the patient should be able to walk for half an hour or even a full hour without pain; movement in the hip should be restored to 90 degrees of flexion and 30 degrees of abduction. In contrast, most of the patients with a poor result have almost no movement in the hip; the stiffness is commonly accompanied by an adduction deformity which advances despite the usual orthopaedic measures. Such poor results are easily explained if one considers the new mechanical conditions after Whitman's reconstruction. The femoral neck, which is about 30 millimetres in diameter, articulates with an acetabulum which is at least 50 millimetres in diameter. Furthermore, in spite of transplantation of the trochanter, the stump of the femoral neck does not always approximate to the inner wall of the acetabulum and so may remain in simple contact with the outer part of the acetabular roof in a position which favours shortening and adduction. If we operate again upon such hips we find that around the cut surface of the femoral neck there is connective tissue and new bone similar to fracture callus, together filling the acetabulum and leading to fibrous ankylosis. The retention of all the femoral neck or even of part of the femoral head, and the interposition of fascia lata or other material, reduce only slightly these imperfect results.

We thought that a more rational arthroplasty would consist in replacing the femoral head by an artificial one of the same dimensions, solidly fixed to the femoral neck. It has been our aim in this way to place between the femur and the pelvis a large and non-absorbable prosthesis and to restore stability and good function to the reconstructed joint.

THE PROSTHESIS

Design—The shape resembles that of a mushroom with a rounded head and a long stem (Fig. 2). The outer surface of the head forms two-thirds of a sphere and is highly polished. The under surface of the head is hollowed out to allow it to fit on the stump of the neck of the femur. The stem is long enough to traverse the remainder of the neck and penetrate the lateral cortex of the femur. For simplicity, the heads are made in three different sizes, each with three different lengths of stem. In this way a prosthesis for any case is always available.

Materials—Rather than metal we have preferred to use an acrylic resin, methyl polymethacrylate, which is a polymer of methyl acrylic acid:



This plastic is not attacked by organic acids and is unaltered by a long stay in the body.

Thermal and electrical conductivity is low. Its hardness is rated at 17·5 on the Brinell scale—about one-quarter that of mild steel. Its resistance to shock may be expressed as follows: a thickness of 4 millimetres resists the shock of a steel ball weighing 300 grammes dropped from a height of 91 centimetres; a thickness of 8 millimetres resists the shock of a similar ball falling through 178 centimetres. With these properties it is clearly suited to be a substitute material for bone.

In twelve of our early patients the stem of the prosthesis fractured after operation. To increase strength and stiffness we therefore re-designed the prosthesis with a steel core, which is completely surrounded and insulated by the acrylic resin. The co-efficients of expansion of these two substances are almost the same at body temperatures; in addition it has been demonstrated by polarimeter measurement that the tensions developed at the steel-resin interface are insignificant. The reinforcement has quite eliminated the risk of fracture.

Tissue tolerance of methyl methacrylate—The physical and mechanical properties of a substance do not alone justify its use as an internal prosthesis; tolerance by the tissues of the body is also an essential requirement. Hitherto almost every foreign substance introduced permanently into the body has been poorly tolerated and has produced an unfavourable reaction in the

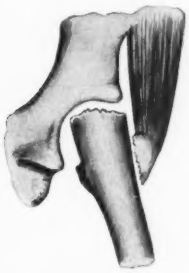


FIG. 1

Whitman reconstruction. The indifferent results of this operation in the author's hands inspired the prosthetic replacement operation. (Illustration by courtesy of Sir Reginald Watson-Jones.)

FIG. 2

The acrylic prosthesis. The stem is reinforced with a steel rod, totally enclosed within the plastic. Without this reinforcement the stem was apt to break.

surrounding tissues; " Vitallium " has for some time been a striking exception. More recently, investigations have shown that polymethacrylate is almost completely innocuous. Oto-rhino-laryngologists who have used polymethacrylate prostheses have been impressed by the absence of adhesions and of connective tissue reaction. From animal experiments, Virenque and his assistants (1947) have shown that " in muscles and in the peritoneum an acrylic resin gives rise only to a temporary reaction," and conclude that " the perfect and astonishing tolerance of acrylic resin is an established fact." Our own experience supports these conclusions. In each of the twelve early cases mentioned above, in which a second operation was necessary because the prosthesis broke, specimens of synovial membrane, capsule and bone were taken for histological examination. Clinically no signs of inflammation were detected in any of these patients; sinus formation did not occur even when part of the broken prosthesis became superficial and without muscle cover. The tissues removed at operation showed little variation from their normal structure.

From the radiological aspect, a somewhat inconvenient property of polymethacrylate is its translucency to X-rays. On the other hand this allows complete examination of the structure of the bone in contact with the prosthesis. In 150 cases observed over various

periods between six months and three and a half years, no osteoporosis of bone has been visible in the radiographs. This record, and the fact that none of the stems has loosened, lead us to expect that the sound fixation of the prosthesis in the femur secured at operation will be maintained indefinitely. The failures that have been reported with other materials (Robineau 1926) were due to a rarefying osteitis which was caused by these materials and which allowed the prosthesis to become loose in the femoral neck.

OPERATIVE TECHNIQUE

The exposure—In order to obtain good movement later we believe that it is essential to avoid all damage to muscle and bone. We therefore use Huter's vertical incision, which extends about 15 centimetres down from the anterior-superior iliac spine, passes between tensor fasciae latae and sartorius, then lateral to rectus femoris and down to the capsule. Branches of the anterior circumflex artery are usually found in the lower angle of the wound and may need to be ligated. The capsule is freely exposed over its anterior, superior and inferior aspects with a blunt instrument.

Excision or incision of the capsule—The capsule is always pathological and adherent to the head and neck of the femur. When grossly abnormal it is resected; in other cases we prefer to make a cruciate incision, which allows dislocation of the head. The capsule having been freely opened, a retractor is slid round each border of the neck to give full exposure of the head and acetabulum.

Resection of the head—Two methods may be used. When the acetabulum is shallow and the head tends to subluxate, dislocation is completed and the head resected with a chisel. When the acetabulum is deep the neck is divided at its junction with the head, and the head extracted with Mathien's hook and Lambotte's spoon. Any residual osteophytes are excised, particularly those so frequently found near the lower margin of the femoral head in osteoarthritis.

Treatment of the acetabulum—Inspection of the acetabulum is made easier by medial rotation and slight flexion of the femur. If the roof is oblique, or if the lower part is more or less filled with bone, the necessary amount is hollowed out with a simple reamer driven by hand (Fig. 3*b*) or by an electric motor. The reamers we have designed are similar in shape to the plastic heads, though the diameters are slightly larger. It is preferable that the head should have free play in the acetabulum and not fit too snugly. In cases of chronic arthritis, such hollowing out of the acetabulum is necessary in two-thirds of the cases.

Drilling and preparation of the neck—The femoral neck is traversed with a drill one millimetre less in diameter than the stem of the prosthesis—a point of vital importance. The lower cortex of the femoral neck is a useful guide. The outer cortex of the femur is perforated, and the length of the tunnel indicates the appropriate length of stem. The common dimensions are 6, 7 and 8 centimetres.

In order that the hollowed-out under-surface of the plastic head should fit the neck closely at the point of section and derive some support from it, the end of the neck is modelled with a special cutter centred on the axial tunnel (Fig. 3*a*). The stem of the prosthesis is now gently hammered into the bony tunnel till the head is well seated on the neck of the femur. An aluminium punch with a large concave head (Fig. 3*d*) is used to avoid damaging the highly polished surface of the prosthesis. Should the bevelled end of the stem project much beyond the cortex of the femur, a small incision may be needed in order to trim the acrylic tip. On no account should the length of stem be so much in excess that the metal reinforcement also projects, as the steel rod cannot be cut close to the bone.

To reduce the new femoral head into the acetabulum, traction is applied to the leg, which is then rotated inwards and abducted. A Murphy's skid is sometimes helpful. If the capsule has not been resected, it is repaired with a few catgut sutures. The muscles fall into position, and the aponeurosis is sutured with care that the lateral cutaneous nerve of the thigh is not included.

Post-operative treatment—Previously it was our practice to immobilise the hip in plaster for three weeks. More recently a simple suspension frame has been used, and mobilisation begun between the tenth and twelfth days. The apparatus allows four movements which the patient can control by means of ropes—elevation of the whole limb, flexion of the knee alone, simultaneous flexion of the knee and hip and, finally, abduction and adduction. Massage is started at the same time and after three weeks the patient begins to walk, at first with the help of a nurse, then alone with two sticks and soon with a single stick.

RESULTS

The rate of recovery of function is very variable. Age, muscle tone, the regularity of the post-operative exercises and the will-power of the patient are important factors. In half the cases the range of movement after two or three months is excellent, and light work may be resumed. In other cases recovery is slower and partial incapacity lasts six to eight months.

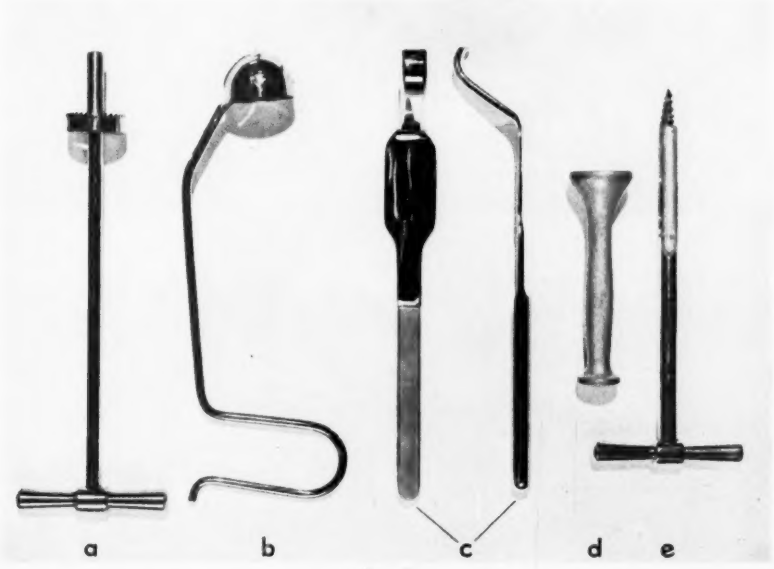


FIG. 3

Some of the instruments used in the operation: (*a*) cutter for shaping femoral neck, (*b*) reamer for acetabulum, (*c*) two aspects of a retractor for neck of femur, (*d*) concave-headed impactor for driving prosthesis into femoral neck, (*e*) hand drill for femoral neck.

Pain—In no case has the pain been made worse by operation. Seven patients out of ten have either no pain or a negligible amount. This freedom from pain is quite remarkable when one remembers that intensity of pain is the main indication for operation. Patients with bilateral arthritis have often requested early operation on the other side.

Three patients out of ten still have pain, which is, however, moderate in degree and tolerable. The pain is usually referred to the lateral or anterior surface of the hip; it may be felt after lying down or sitting and may diminish after a few minutes of activity. Local infiltration of novocain and, occasionally, radiotherapy may give some relief. Even in these less satisfactory cases walking and other activities can be sustained for longer periods than previously.

FIG. 4

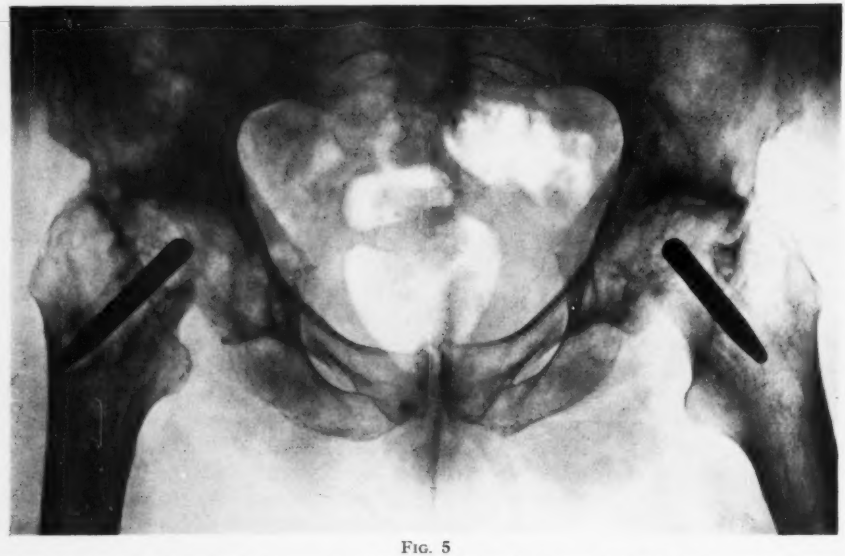


FIG. 5

Case 1. Female aged seventy-two years. Bilateral osteoarthritis. Figure 4—Condition before operation. Figure 5—Condition after excision of femoral heads and replacement with acrylic prostheses.

FIG. 6

FIG. 7

Case 2. Female, aged fifty-seven years. Osteoarthritis. Figure 6—Before operation. Figure 7—Two and a half years after operation. An early-type prosthesis, without metal reinforcement of stem, was used. Position of stem is indicated by condensation of surrounding bone.

FIG. 8

FIG. 9

Case 3. Ununited fracture of femoral neck. Subtrochanteric osteotomy was unsuccessful in relieving symptoms. Painful pseudarthrosis (Fig. 8). The head was excised and replaced by an acrylic prosthesis. The track of the stem can just be seen in Figure 9.

FIG. 10

FIG. 11

Case 4. Female, aged twenty-six years. Congenital dislocation of left hip. Unsuccessful shelf operation. Note marked upward displacement of femoral head (Fig. 10). A new acetabulum was formed in normal position; the head was excised and replaced with an acrylic prosthesis (Fig. 11).

Movement—With regard to flexion, 60 per cent. of patients reach or pass 90 degrees; 30 per cent. have from 60 to 90 degrees; and only 10 per cent. fail to obtain 60 degrees of movement. Abduction is never less than 20 degrees, and the fixed adduction deformity so frequent after a Whitman's resection has not been seen. The range of medial and lateral rotation is about half the normal.

Walking—One-third of the patients do not require a stick, but two-thirds do. The return of function is variable but often remarkable; 80 per cent. of patients are able to return to work, and some can walk several miles, ride a bicycle and do a heavy day's work.

INDICATIONS

The " resection-reconstruction " operation is suitable for the treatment of four types of lesion: osteoarthritis, ununited fracture of the femoral neck, non-tuberculous ankylosis and dislocation of the hip. Patients of any age can undergo this operation; we judge their fitness on the general state of health and on the results of routine laboratory tests. Three deaths have occurred after 300 operations, possibly from improper selection. One patient of seventy-three years died on the third day, but the autopsy revealed no special cause. The second death was caused by uraemia during the third week, and the last by cerebral softening in the seventh week.

Osteoarthritis (Figs. 4 to 7)—This is much the commonest condition requiring operation, and in these cases the principal indication is pain that has failed to respond to conservative treatment. Operation is reserved for those whose activities by day and rest by night are badly disturbed, though an adduction contracture or bilateral fibrous ankylosis are secondary indications.

Ununited fracture of the femoral neck (Figs. 8 and 9)—This is the second most important indication. So far, we have operated on twenty of these cases with such success that we consider the treatment to have no equal for ease and speed. For special reasons we have twice treated recent fractures in the same way, and again both gait and range of movement have been excellent. We must add that after non-union the neck is often decalcified or reduced to a small stump; the great trochanter should then be displaced by Whitman's procedure in order to give lengthening of the neck. The degree of upward displacement of the femur is of no importance.

Non-tuberculous ankylosis of the hip—In such cases the femoral neck is divided with a curved chisel close to the ilium, which is then hollowed out in order to form a new acetabulum. The operation is successful when muscle power is adequate.

Dislocation of the hip (Figs. 10 and 11)—For an old congenital dislocation with pain, the original acetabulum is deepened and the head of the prosthesis reduced into it. Sometimes a new acetabulum has to be created at a higher level. The operation is suitable also for cases of dislocation after infective arthritis of infancy when the head has already been destroyed.

CONCLUSIONS

We have endeavoured to make known the results of a simple type of arthroplasty of the hip which is well tolerated even by elderly patients. It has not been the purpose of this article to compare former operations with our own, a newcomer in the field of surgery of the hip. In particular we do not wish to compare our comparatively recent results with Smith-Petersen's well-established method of cup arthroplasty—a magnificent contribution to the surgery of the region. The results we have already obtained, however, appear sufficiently favourable to merit further study and development of the method. If the future confirms the value of our early results, we shall perhaps be able to suggest operation to patients who suffer more from loss of function than from pain.

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THE TREATMENT OF QUIESCENT TUBERCULOSIS OF THE HIP JOINT BY EXCISION AND "DYNAMIC" OSTEOTOMY

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After the First World War it came to be recognised that in the treatment of tuberculosis of the hip, operation was usually necessary sooner or later; the operation most generally favoured was arthrodesis. The reasons that led to this conclusion are well known, and their almost universal acceptance has diverted attention from the functional disability that the patient suffers from the loss of a major and highly mobile joint. The views expressed at the Congress of the International Society of Orthopaedic Surgery and Traumatology held in London in 1933 almost universally favoured arthrodesis. At this meeting, the author, while advocating extra-articular arthrodesis for relatively recent cases, recommended osteotomy with excision of the stump of the neck of the femur for all types of late pseudarthrosis resulting from destruction of the joint. Several cases were reported of quiescent bilateral disease treated by this type of arthroplasty.

It is not disputed that successful arthrodesis is far superior to conservative treatment alone. Nevertheless, the stiff joint often leads to secondary derangements such as lumbar backache and ligamentous laxity of the knee, while the patient may also fracture the femur on the affected side. Another disadvantage is the need for some months of complete post-operative immobilisation. Arthrodesis is contra-indicated when there is disease of the lumbar spine or of the other hip.

We have now come to the conclusion that the best results are obtained when all infected tissues are removed during the quiescent phase of the disease by excising the remains of the head and neck of the femur, of the capsule and of the acetabulum; good function may then be re-established by remodelling the upper end of the femur. This method has been developed since 1929 and our results in ninety cases were reported in 1946 at the meeting of the International Society in Brussels. Until 1948 we secured the osteotomy fragments with wire, but immobilisation in plaster for three months after this operation had obvious disadvantages when the aim was a mobile joint. For this reason a new and better technique has been evolved, based on fixation of the osteotomy by a plate and screws—an advance for which we are indebted to Dr J. Thomson, of Lincoln, Nebraska.

ANATOMICAL CONSIDERATIONS

The axis of flexion and extension of the normal hip joint passes through the centre of the femoral head and the tip of the great trochanter. The insertions of the gluteus medius and gluteus minimus into the trochanter are along this ideal axis (Fig. 1). If the trochanter is elevated above the axis, as in coxa vara, these muscles become less effective and the range of abduction is reduced. The second important point is the distance between the centre of the femoral head and the tip of the trochanter, that is, the lever arm of the abductors. Normally this distance is five to seven centimetres; if the muscles are weak a longer lever arm is an advantage. The third consideration is the distance from the point of support, that is, the centre of the femoral head to the perpendicular through the centre of gravity of the body. The longer this distance, the greater the force that must be exerted by the abductors to maintain equilibrium of the pelvis in walking. If the abductors are weak this distance should, if possible, be shortened.

The new joint should reproduce the normal static and mechanical conditions except

that: 1) no weight should be borne by the old acetabulum; 2) the lever arm of the abductors should be longer than normal to compensate for the loss of power in these muscles; and 3) the point of support of the pelvis should be shifted towards the axis of the body. These requirements can be fulfilled by excision of the hip joint followed by a step-cut osteotomy of the upper end of the femur; the upper fragment is angulated to support the pelvis at a point beneath the acetabulum (Figs. 1 and 2).

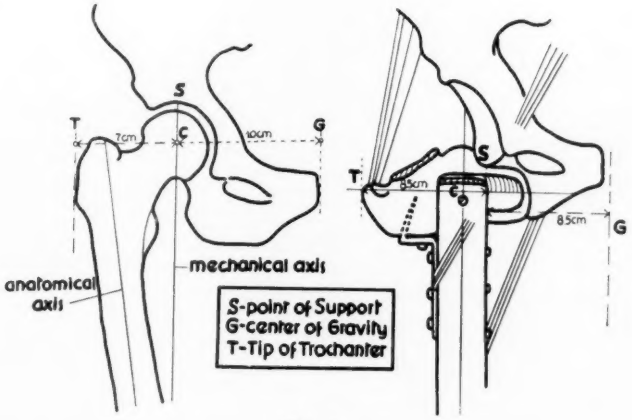

FIG. 1

Mechanics of the normal hip joint (*left*), and of the pseudarthrosis after "dynamic" osteotomy (*right*).

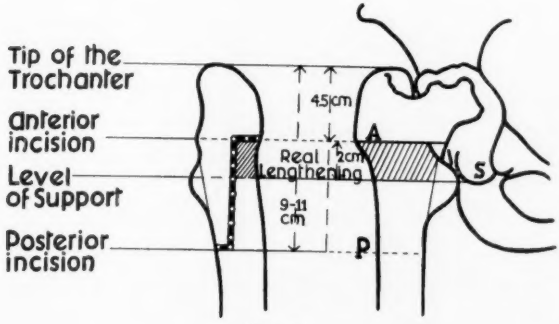

FIG. 2

Calculation of the level of osteotomy.

TECHNIQUE OF OPERATION

Pre-operative measurements—These are made from a radiograph which includes both hips. If there is no subluxation and no shortening, the anterior line of hemi-section of the femur is made level with the inferior margin of the acetabulum, about four centimetres below the tip of the great trochanter; but if shortening is present, the section may be made up to two centimetres higher. The posterior hemi-section of the femur is made nine to eleven centimetres below the tip of the trochanter, depending on the stature of the patient.

Position—The patient is placed supine on an orthopaedic table. The normal limb is fixed to the extension device; the affected limb remains free. The table is tilted laterally so that the field of operation is facing upwards.

The surgical approach—Ollier's goblet incision is made from the anterior-superior spine to the base of the trochanter and thence for five centimetres backwards along the fibres of the gluteus maximus. After division of the skin and fascia, a vertical incision twelve centimetres long is added from the base of the trochanter down the posterior border of the vastus lateralis. The tensor fasciae latae is separated by blunt dissection from the glutei. The abductors are lifted upwards and are detached, together with a thin flake of bone, from the trochanter (Fig. 3). The anterior surface of the capsule is then cleared by blunt dissection.

Excision of the joint—The capsule is incised along the intertrochanteric line and along the upper and lower margins of the neck. With the aid of a raspatory, this flap of capsule is stripped up to the acetabular rim. The remaining capsule is separated from the femoral neck, under which bone levers are inserted. Adhesions of the femoral head to the acetabulum are divided with a curved chisel, and the head is dislocated. If mobilisation of the head is difficult, section of the femoral neck at the intertrochanteric line is carried out first, and the head removed separately. The synovial membrane and all diseased soft tissues are removed and the acetabulum is curetted down to healthy bone with special reamers (Fig. 4).

The posterior capsule is excised, bleeding from the bone is controlled, and the acetabular cavity is covered by folding in the anterior flap of capsule. With the limb in extreme external rotation, the tendon of the iliopsoas is exposed and divided, and then transfixed with two strong silk threads in readiness for transplantation.

The osteotomy—The hip is now extended and the incision deepened along the margin of the vastus lateralis. The anterior and lateral surfaces of the femur are cleared at the levels of the osteotomy, which are marked out with a chisel. When there is no shortening, the antero-superior line of hemi-section of the femur is between three and a half and four and a half centimetres below the tip of the greater trochanter, or half a centimetre below the transverse gluteal ridge. If shortening is present, lengthening of the femur of at least two centimetres can be obtained by traction. Thus the upper end of the shaft of the femur is brought down level with the lower margin of the acetabulum. If this fragment is too long it must be adequately shortened. The postero-inferior line of hemi-section is marked at eleven centimetres—in children six to seven centimetres—below the tip of the trochanter.

When the correct levels of section have been calculated, the upper end of the Z-shaped metal plate is driven into the trochanteric mass and secured by a screw (Fig. 5). The bed for the metal plate is prepared by a small chisel driven into the bone in the required axis.

The Z-line of section of the bone is next marked out by drill holes (Fig. 5). The bone is cautiously divided through half its diameter along the upper and lower transverse lines, and then split longitudinally. Care must be taken to avoid fracture of the femur.

Re-alignment and fixation—Traction is applied to the limb. By using the spike in the trochanter the upper fragment is placed in extreme adduction with its lower end pointing towards the obturator foramen. The position of the limb is then so adjusted that the two fragments form a right angle, and this position is maintained temporarily by a clamp. The plate is fixed securely to the femur by two or more screws, and a final antero-posterior screw holds both fragments together where they cross (Figs. 3 and 6).

The iliopsoas tendon is sutured under moderate tension to the posterior periosteum of the femur (Fig. 6). The reflected part of the vastus lateralis is sutured to the periosteum of the upper fragment and the lateral part to the fascia of gluteus medius (Fig. 7). The wound is closed in layers with catgut and the hip is immobilised in a plaster spica.

FIG. 3

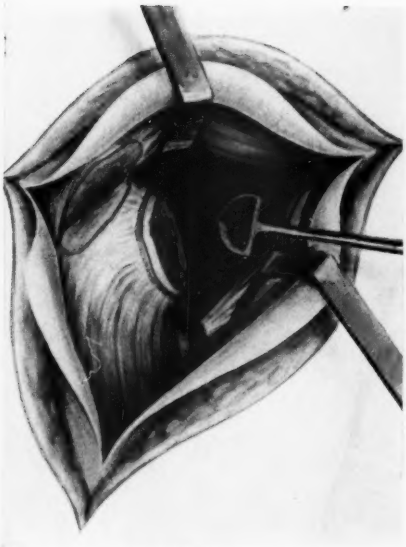

FIG. 4

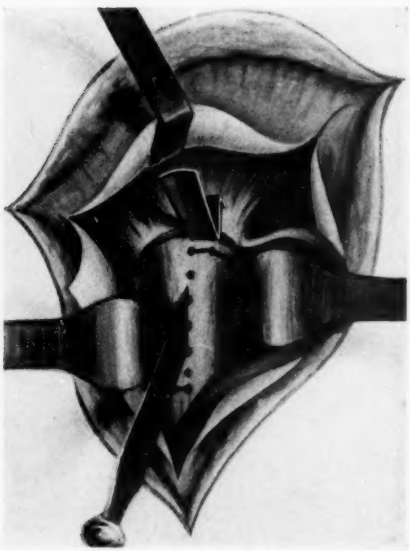

FIG. 5

Figure 3—The abductors are detached, with a thin flake of bone, from the trochanter. Figure 4—The acetabulum is curetted down with special reamers. Figure 5—The Z-shaped plate is driven into the trochanteric mass and fixed with screws. The bone is divided through half its diameter and then split longitudinally, along a line of drilled holes.

Post-operative treatment—Six weeks after operation the spica is removed, a radiograph is taken, and passive movements, massage and radiant heat baths are begun. Full weight-bearing and unrestricted exercises are permitted after twelve weeks.

Importance of rehabilitation—Before 1947 no special after-treatment was given and the plaster was retained for three months. After removal of the plaster the patient was allowed up with or without crutches. In many patients with relatively recent disease the range of movement after removal of the plaster was fairly good and became almost normal within a few months. On the other hand, cases of long-standing fibrous or bony ankylosis regained movement slowly after three months of immobilisation, and many patients developed flexion or abduction contractures which persisted for several months. For these reasons patients with long-standing disease are now given a course of baths, massage and exercises before operation, and the period of immobilisation has been reduced to six weeks.

Complications—An important complication is *fracture* of the upper end of the diaphysial fragment. If this should happen, the fractured fragment must be fixed by screws to the metal plate; union is delayed and a longer period of immobilisation is necessary. If an *abscess* is encountered it is curetted; the risk of sinus formation is small. *Haemorrhage* may occur from branches of the circumflex artery. As a result of this operation the anatomical axis of the limb approximates to the mechanical axis; for this reason any pre-existing valgus deformity of the knee is accentuated. In a few cases genu valgum has required correction by supracondylar osteotomy.

RESULTS

The results are given in Table I. Between 1932 and 1949, 224 hips have been operated upon, 208 by the technique reported in 1946 and sixteen by the new procedure. One adult patient died from cachexia eighteen months after operation; extensive necrosis of the skin and muscles developed in the trochanteric region and later a focus in the ilium was discovered. There were no deaths in the immediate post-operative period.

TABLE I

ANALYSIS OF 224 CASES

Age of patients in years	4 to 50
Wire fixation of osteotomy	208
Plate fixation of osteotomy	16
Post-operative mortality	0
Late mortality	1
Delayed union of osteotomy	3
Septic infection	5
Sinuses	3
Relapse of tuberculous infection	4
Bony ankylosis	3
Fibrous ankylosis	6
Poor early results	25
Poor late results	5
Satisfactory end-results	219

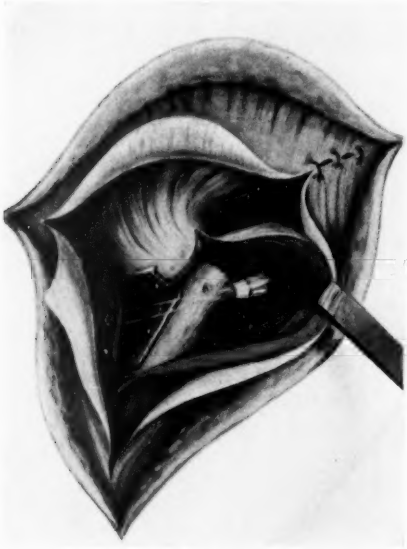

FIG. 6

FIG. 7

Figure 6—The upper fragment of the trochanter is placed in extreme adduction and the position of the limb adjusted so that the two fragments form a right angle. The iliopsoas tendon is sutured to the posterior periosteum of the femur.
Figure 7—The reflected part of the vastus lateralis is sutured to the periosteum of the upper fragment and the lateral part to the fascia of gluteus medius.

FIG. 8

FIG. 9

Case 1. Child aged six years. Tuberculosis of left hip. Figure 8—before operation. Figure 9—ten months after operation.

Delayed union was observed in three cases and was due to fracture of the upper end of the diaphysial fragment. There were fractures in other cases but these all united within three months. Septic infection developed in five cases, in all of which the late results were satisfactory; the incidence of infection is very small in relation to the number of cases in which secondary infection was present before operation. Sinuses were observed in three cases early in the series, but there has been no such trouble during the last five years. Relapses occurred in four cases; in three there was a tuberculous focus in the trochanter which healed after evacuation of the abscess and general treatment. One patient was readmitted four years after operation with a septic focus in the acetabulum and a sequestrum which was removed. Bony ankylosis occurred in three patients. Fibrous ankylosis was more common, but only in six cases was it necessary to divide adhesions in order to correct deformity. Fibrous ankylosis tends to disappear spontaneously after some years and for this reason no secondary operation is performed if the position of the limb is correct.

It will be seen that the early results were satisfactory in nearly 90 per cent. of cases; these patients had a painless stable joint and a range of movement varying from 40 to 100 per cent. of normal (Figs. 8 to 11). In one-third of these cases there was shortening of the affected limb up to two centimetres, but many patients had real lengthening of one to two centimetres.

FIG. 10

FIG. 11

Case 2. Female aged twenty-nine years. Tuberculosis of right hip. Figure 10—before operation. Figure 11—ten months after operation.

DISCUSSION

At the beginning of the study this operative technique was reserved for mobile subluxations and dislocations of the hip joint; for intra-articular pseudarthrosis of the type described by Bouvier and Ménard; for cases of bilateral tuberculosis of the hip; and for cases with disease of the hip and knee in the same limb, or with co-existing tuberculosis of the hip and lumbar spine. More recently, as our experience has increased, almost all adult cases of quiescent tuberculosis of the hip have been subjected to operation. In children the operation has been employed only when the chance of healing with a good range of movement was remote. Thus excision of the joint and " dynamic " osteotomy is now our routine operation, and arthrodesis has not been performed during the last ten years.

Provided bone atrophy is not too pronounced the improved technique with fixation of the fragments by a metal plate makes it possible to undertake the operation even in long-standing cases with ankylosis in faulty position dating from childhood. Since early movement has no adverse influence on union of the plated osteotomy, ankylosis is unlikely to recur. Nevertheless, in these long-standing cases recovery of movement is relatively slow.

When ankylosis in good position has occurred the operation is not advised unless there is some special indication for mobilisation of the joint. In non-tuberculous conditions for which vitallium cup-arthroplasty is contra-indicated, we follow the same procedure, as, for example, in ankylosing spondylitis and in neglected congenital dislocation of the hip.

The operation is contra-indicated: 1) in the active stage of tuberculous disease; 2) in the presence of infected sinuses; if treatment with penicillin and streptomycin fails, the excision of infected bone is carried out first and the osteotomy is performed some months after healing of the sinuses; 3) where there is gross atrophy of bone and muscle after tuberculosis in early childhood; and 4) when the general condition is unsatisfactory.

SUMMARY

1. The operation of " dynamic " osteotomy is designed to secure a stable and freely mobile pseudarthrosis in cases of quiescent tuberculosis of the hip joint.
2. The principles and technique of the operation are described and illustrated.
3. The results of 224 operations are presented.

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POSTERIOR EXPOSURE OF THE HIP JOINT

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So much attention has been focused in recent years upon the anterior approach to the hip joint that the advantages of the posterior approach have been ignored almost entirely and many surgeons have no experience of it. The descriptions given in some standard text-books are incomplete or even inaccurate. Moreover, the impression is prevalent that haemorrhage during the operation may be troublesome. This view cannot possibly be entertained by anyone who is familiar with the procedure. A few small vessels may have to be clamped, but it is seldom necessary to apply a ligature.

To anyone who is not well acquainted with the anatomy of the buttock the description of the operation may sound complicated; but in reality the anatomical simplicity is most striking. The earliest account of a posterior exposure is that of von Langenbeck (1874). The patient was laid upon the sound side with the affected hip flexed 45 degrees, a position in which the axis of the thigh corresponds approximately with a line joining the greater trochanter with the posterior superior iliac spine. The incision began in this line, three finger-breadths proximal to the tip of the greater trochanter, and extended about three finger-breadths down the line of the thigh (Fig. 1). While the wound was retracted the lower limb was rotated outwards and inwards to facilitate detachment of the muscles and capsule from the trochanter and neck of the femur. The ligamentum teres was cut or torn across, and the head of the femur was dislocated from the acetabulum.

FIG. 1
Langenbeck incision.

The Langenbeck approach was modified by Kocher (1907). The first edition of Kocher's " Operative Surgery " was published in 1892, but the earliest description of his approach to the hip joint that I have been able to find is in an article by his pupil Dumont, published with Kocher's permission in 1887. All Kocher's incisions served the fundamental principle—*primum non nocere*; they were designed to pass between adjacent nerve territories. In the hip joint the tissues were separated between the territories of the superior and inferior gluteal nerves—between the gluteus medius, gluteus minimus and tensor fasciae latae on the one hand and gluteus maximus on the other. The skin incision was angled. Beginning at the upper anterior border of the greater trochanter, its lower or vertical limb extended distally along the line of the shaft of the femur; the upper limb passed obliquely backwards towards the posterior superior spine along or near the upper border of the gluteus maximus.

Kocher's work was translated into English by Stiles (1911); during the life-time of the translator, Kocher's approach to the hip joint was widely employed in Great Britain but was never well known in the United States of America or in Canada. On the continent of Europe it is still first in favour (Klapp 1923). During the last thirty-five years a modification of Kocher's posterior approach has been used by the present writer as a routine procedure; in the belief that the exposure has outstanding advantages, he has therefore undertaken the following detailed description.

TECHNIQUE OF OPERATION

The patient is placed upon the sound side in the lateral position; "kidney supports" ensure that the position is maintained securely throughout the operation. The skin incision is shown in Figure 2. Only two landmarks are necessary—the posterior superior spine of the ilium and the upper anterior angle of the greater trochanter (Fig. 3). The gluteus maximus is attached to the crest of the ilium for about two inches in front of the posterior superior spine. The upper part of the skin incision outlines the upper border of the muscle and should be arched slightly forwards from a point two and a half inches in front of the posterior superior spine to the upper anterior border of the greater trochanter; the lower part extends distally along the line of the thigh for six or seven inches. The first incision divides skin and subcutaneous fat; small vessels may require clamping. The flaps are reflected backwards and forwards for a short distance to display clearly the gluteo-femoral fascia.

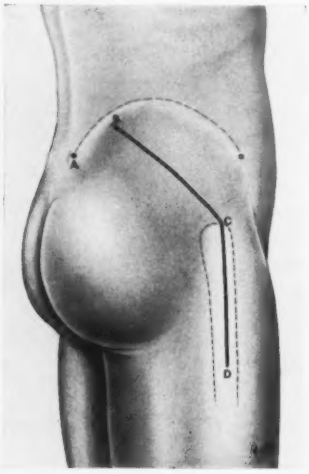

FIG. 2

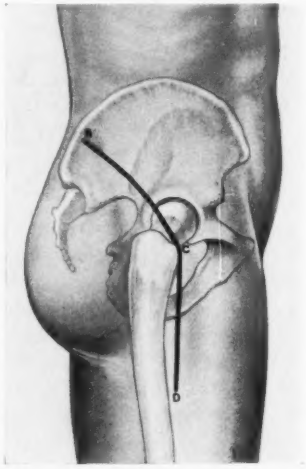

FIG. 3

Modified Kocher incision. The upper half of the skin incision is arched slightly forwards (Fig. 2). It corresponds approximately to the anterior border of the gluteus maximus. Figure 3 shows the relation of the skin incision to the underlying bones.

The next step (Fig. 4) is to incise the deep fascia vertically in the lower half of the incision. The posterior flap is raised, defining the upper border of the gluteus maximus. The gluteal fascia is divided along this border. The whole mass formed by gluteus maximus and its aponeurotic prolongation into the fascia lata is retracted backwards. Separation of its deep aspect is made easy by the large bursa which lies between the tendon of gluteus maximus and the upper posterior part of the femur. It is not always necessary to reflect the muscle as high as the crest of the ilium. We now have a dissecting room view of the gluteal region: the muscles attached to the greater trochanter—gluteus medius, gluteus minimus, piriformis, obturator internus and gemelli, obturator externus and quadratus femoris—are all clearly defined.

The next step is to detach these muscles from the greater trochanter. Those supplied by the superior gluteal nerve (gluteus medius and gluteus minimus) are retracted forwards, and the others backwards. The posterior border of gluteus medius is easily demarcated from the piriformis by blunt dissection (Fig. 5). The gluteus medius is followed down to its attachment to the outer side of the greater trochanter and is detached; the insertion is

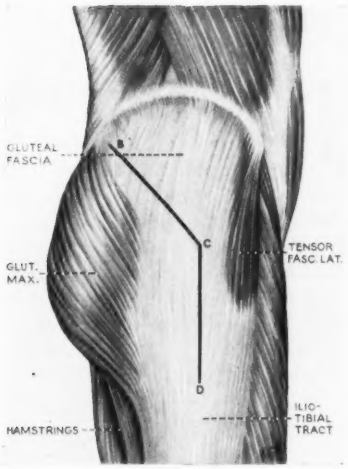

FIG. 4

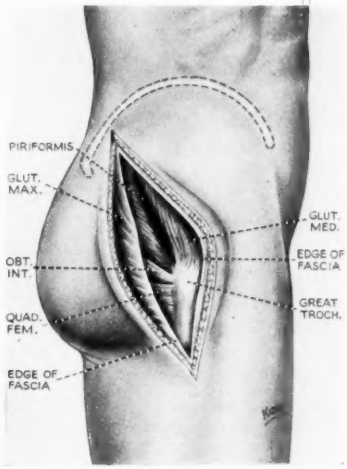

FIG. 5

The gluteal fascia is divided in the same line as the skin incision (Fig. 4). The whole mass of the gluteus maximus with its aponeurotic prolongation is then easily retracted backwards, exposing the short transverse muscles attached to the greater trochanter (Fig. 5).

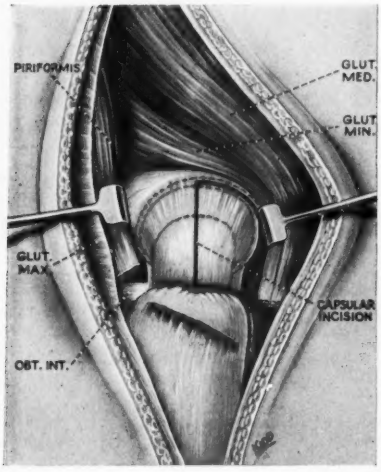

FIG. 6

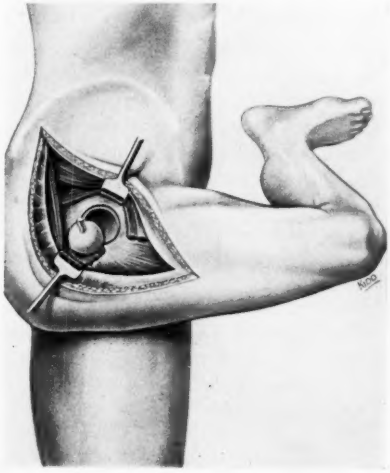

FIG. 7

The short muscles have been detached from the great trochanter and retracted to expose the capsule of the hip joint which is incised and reflected anteriorly by detaching it from the margin of the acetabulum and base of the neck of the femur (Fig. 6). The head of the femur is dislocated by flexion, adduction and external rotation of the limb (Fig. 7).

tendinous and there is little bleeding. By rotating the thigh outwards it is easy to detach the insertion of gluteus minimus from the anterior surface of the greater trochanter in a sheet continuous with the attachment of gluteus medius. Similarly, the insertion of piriformis to the tip of the greater trochanter is divided; if necessary the insertion of the external rotators is also severed. Detachment of the quadratus femoris is seldom necessary. When the muscle insertions have been detached and retracted all aspects of the capsule of the joint are exposed in the bottom of the wound.

The joint capsule is incised superiorly in the line of the neck of the femur from its upper attachment at the rim of the acetabulum to its distal attachment at the base of the neck (Fig. 6). By rotating the limb it is a simple matter to detach the whole capsule from the anterior rim of the acetabulum and from the anterior inter-trochanteric line. The posterior part of the capsule may also be incised, but this is not essential.

The final step in the exposure is to dislocate the head of the femur from the acetabulum by flexing the thigh and rotating it laterally (Fig. 7). Occasionally it may be necessary to chisel osteophytes from the acetabular rim in order to permit disengagement of the head of the bone. The ligamentum teres is usually ruptured. The manoeuvre of dislocation is performed by an assistant whose duty it is to control the position of the limb so that the head of the femur and cavity of the acetabulum are easily accessible.

COMMENT

The advantages of the posterior approach are that it is rapid, almost bloodless and attended by little shock. The power of the muscles is unimpaired, for they are not detached from an extensive iliac origin as in the Sprengel " Beckenrand " approach (1897). The gluteus maximus and tensor fasciae latae, which are so important for stability of the hip, are not weakened and the operation causes no instability.

The original purpose of this exposure, as used by Langenbeck, was to secure drainage in suppurative arthritis. In Kocher's hands it was employed to give full and free access to the acetabulum in the surgical treatment of tuberculosis of the hip joint. In modern surgery it has a still wider field of usefulness. In posterior fracture-dislocations of the hip joint, direct exposure of the site of the injury is gained. When operation is required to secure replacement of a slipped upper femoral epiphysis the posterior part of the joint with the displaced epiphysis is exposed readily. The approach is ideal for exposure of the sciatic nerve in the buttock, and for dealing with injuries of the gluteal arteries. In arthrodesis of the hip joint the anterior flap may be retracted to allow access to the ilium which may be required for use as a graft, and the field of implantation of the graft is displayed with the least possible trauma. In cup-arthroplasty of the hip joint the simplicity and efficacy of the method give the most useful application of all.

It is not too much to say that as a routine procedure for exposure of the hip joint the posterior approach is *facile princeps*.

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ISCHIO-FEMORAL ARTHRODESIS OF THE HIP IN TUBERCULOSIS

An Anterior Approach

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The operation to be described here is a modification of the ischio-femoral arthrodesis described by Brittain (1942). It is performed through an anterior incision, deepened so as to expose the upper part of the shaft of the femur and the ischium. Iliac bone grafts are inserted under direct vision. The evolution of this method of fusing the hip for tuberculous arthritis will be described briefly. At the outset it must be made clear that the writer does not advocate arthrodesis for tuberculous disease until the patient has acquired an adequate

FIG. 1

FIG. 2

Case 1. Tuberculous arthritis of the right hip joint. Figure 1 shows the condition of the hip after immobilisation for twelve months. The patient's general condition was good: ischio-femoral arthrodesis was undertaken. Radiographs taken three months later show good consolidation, with much new bone formation below the graft (Fig .2).

resistance to the disease, nor before there is evidence of healing in the joint. Five years ago we employed the methods of ilio-femoral arthrodesis described by Girdlestone (1940) and others. This operation gave good immediate results when there was no gross destruction of the head of the femur or of the acetabulum. But sound fusion did not occur in less than six to nine months, and observation of these patients over three or four years revealed a marked tendency to adduction of the femur. Moreover the ilio-femoral operation seemed unsuitable for patients in whom there was gross erosion of the head of the femur and of the acetabulum, with upward subluxation of the head. For these reasons we turned our attention to Brittain's (1942, 1948) ischio-femoral arthrodesis with a tibial graft. It gave improved results in cases in which there was marked destruction of the joint, and we have not observed subsequent adduction deformity of the hip. Nevertheless in several cases the graft slipped out of position or the lower fragment of the femur slipped outwards. Though we never encountered post-operative sciatic paralysis, in one operation on a cadaver we found that the graft was only one-quarter of an inch anterior to the sciatic nerve. Fusion was never sound in less than six months, and immobilisation for twelve months was often necessary.

FIG. 3

FIG. 4

FIG. 5

Case 2. Tuberculous arthritis of the right hip joint. Figure 3 shows pre-operative condition of the hip. After many months of conservative treatment the infection was becoming clinically quiescent. Figure 4 shows the condition four months after combined intra-articular and ischio-femoral arthrodesis. Clinically the joint was fused. Radiographs taken one year after operation show good consolidation of the grafts (Fig. 5).

In an attempt to overcome those disadvantages we considered the possibility of using cancellous grafts from the ilium, and of inserting the grafts through an anterior incision. We so aimed to combine the mechanical principles of Brittain with the physiological advantages of cancellous chip grafts described by Mowlem (1944). The operation is technically easier than the previous methods we used; and the graft cannot slip from position. In most cases fusion has occurred within three to four months. In a few cases in which healing of the tuberculous disease was sound, ischio-femoral grafting was combined with intra-articular arthrodesis. In other cases, in which the response to rest and immobilisation was poor, osteotomy of the femur just above the lesser trochanter was performed, and was followed after an interval of months by ischio-femoral grafting.

Radiographs illustrating three cases are reproduced in Figures 1 to 8.

FIG. 6

FIG. 7

FIG. 8

Case 3. Tuberculous arthritis of the left hip joint. Figure 6 shows condition of the hip on admission to hospital. Despite immobilisation the general condition of the patient deteriorated. Osteotomy immediately above the lesser trochanter was followed by general and local improvement (Fig. 7). Ischio-femoral arthrodesis was undertaken six months after the osteotomy; radiographs three and a half months later show a solid mass of new bone (Fig. 8.) Clinically the joint was fused.

TECHNIQUE OF OPERATION

The operation is performed under a general anaesthetic, and a drip transfusion of blood is given throughout. The patient is placed on an orthopaedic table. The anterior incision described by Smith-Petersen (1949) is used, and the muscles are stripped from the outer and inner aspects of the anterior half of the iliac crest. The lower part of the incision follows the outer border of the sartorius muscle and extends to the junction of the upper and middle thirds of the thigh. The deep fascia is incised along the outer border of the sartorius. The origin of sartorius from the anterior-superior spine is divided close to bone, and the muscle is retracted medially to expose the rectus femoris and the fatty line of demarcation between the rectus femoris and iliopsoas (Fig. 9). This interval is developed and the medial border of the rectus femoris is defined (Fig. 10). Numerous branches of the lateral femoral

circumflex vessels are found: they are divided between haemostats and ligated as they are encountered. The heads of origin of rectus are divided close to bone and the muscle is retracted laterally to expose the capsule of the hip joint. A small lever is passed to define the inferior aspect of the joint (Fig. 11).

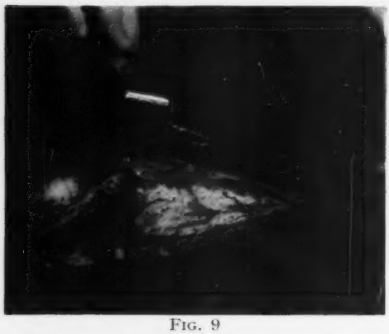

FIG. 9

Anterior incision. The muscles have been stripped from both aspects of the anterior part of the ilium. Sartorius retracted, exposing rectus femoris.

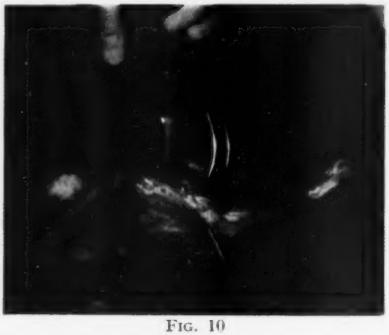

FIG. 10

The interval between rectus femoris and iliopsoas is developed. Branches of the lateral femoral circumflex vessels are ligated.

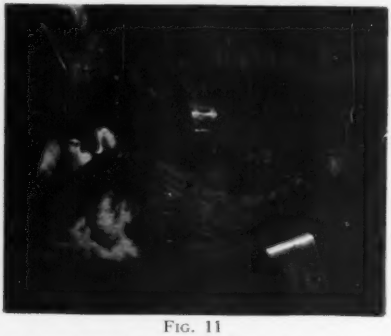

FIG. 11

A bone lever is placed below the hip joint; iliopsoas is retracted medially, and rectus femoris laterally. This allows the inferior aspect of the joint to be defined.

FIG. 12

A lever is pushed through the obturator externus into the lower part of the obturator foramen and retracts the sartorius, iliopsoas, pectineus and adductor magnus medially.

The iliopsoas muscle is reflected from the pubic ramus and from the medial part of the joint capsule and its insertion into the lesser trochanter is defined. A small lever is passed medial to the tendon, which is divided close to its insertion. This step is sometimes made easier by external rotation of the hip to bring the lesser trochanter forwards. The iliopsoas can now be retracted farther medially; and just distal and posterior to the lesser trochanter the fibres of insertion of pectineus and of adductor magnus are separated from the femur for one to one and a half inches.

The obturator externus muscle comes into view deep in the wound, between the capsule of the hip joint above and the pectineus and adductor magnus muscles below. A large bone lever is passed through the fibres of obturator externus on to the ischium and pushed medially until the obturator foramen is encountered. The lever is manipulated into the foramen so that its tip lies behind the ramus of the ischium; its handle is drawn medially to retract the sartorius, iliopsoas, pectineus and adductor magnus (Fig. 12). This manoeuvre opens up the

space between the lesser trochanter and the obturator foramen, and the mechanical leverage is such that retraction can be maintained with least effort by the assistant. A box retractor is passed obliquely medially and posteriorly. It lies between the rectus femoris and the lesser trochanter on the lateral side and the iliopsoas on the medial side.

FIG. 13

A box retractor is passed into the interval between rectus femoris laterally and iliopsoas medially. Ischium is seen through the retractor.

FIG. 14

The upper part of the femur is exposed by stripping vastus intermedius laterally. A curved lever is passed behind the femur.

FIG. 15

A large diameter hole is drilled through the femur towards the ischium.

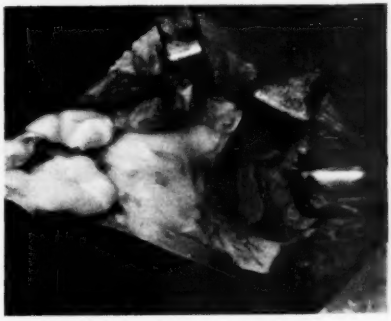

FIG. 16

Iliac graft inserted. The space above and below the graft will be packed with bone chips.

The retractor has four sides, each tapering from a width of one and a half inches at the top to one and a quarter inches at the bottom. Each side is one and a half inches deep. The use of such a retractor greatly facilitates the exposure of the obturator externus in the depths of the wound. The part of the muscle that overlies the ischium is removed piecemeal with scissors or scalpel until the ischium comes into view (Fig. 13). The bone is rawed widely with a chisel under direct vision, the chisel passing through the box retractor. The ischium is then divided, using chisel and mallet. Sometimes this is easier through the box retractor, sometimes division of the bone is easier after removing the retractor. If the ischium is divided at the level of the obturator foramen (the level advised when the lower margin of the acetabulum is diseased), the whole width of the ramus must be divided. When the line of division is above the foramen the chisel should pass deeply into the bone (one to one and a half inches in adults).

In the next step the upper parts of the origins of the three vasti muscles are stripped

from the femur and retracted laterally by a large bone lever passed round the bone. This exposes the antero-lateral aspect of the femur at the level of the lesser trochanter (Fig. 14). A drill hole is made through the femur with a motor drill, directed inwards and backwards towards the ischium (Fig. 15). The size of the hole should be rather less than half the diameter of the femur. If necessary the hole may be enlarged medially with a gouge.

A whole thickness graft is cut from the iliac crest. It measures one to one and a quarter inches in width and three and a half to four inches in length. Owing to the shape of the crest the graft is slightly curved and the posterior end slightly pointed. The wide flat end of the graft is held with sequestrum forceps and placed firmly in the cleft in the ischium. It is important that a firm fit be obtained, and it may be necessary to taper the end of the graft or to enlarge the cleft to a slight extent. At this stage the outer pointed end of the graft lies anterior to the lesser trochanter. The whole limb is now abducted and the outer end of the graft swung backwards until its pointed extremity lies opposite the hole in the femur. The limb is then adducted until the graft fits firmly in the hole in the femur (Fig. 16). Some slight adjustment of the graft or aperture may be necessary in order to obtain a firm fit with the hip joint in the neutral position. After fitting the graft the neck of the femur is rawed by making small cuts with chisel or gouge from below the lesser trochanter to the lower margin of the acetabulum. Small chips are cut from the ilium and packed between the femoral neck and the graft, and also between femur and ischium below the graft. The aim should be to fill in with grafts the space lying below the femoral neck and the acetabular margin, between the femur on the outer and ischium on the inner side. Where the femoral neck and acetabular margin are involved in the disease process it is sometimes wise not to pack the space above the main graft but to concentrate on forming a strong bar of bone at the lower level.

The wound is closed and a double hip spica plaster is applied with the affected hip in the neutral position and the sound hip slightly abducted.

POST-OPERATIVE TREATMENT

Three months after the operation the plaster is removed for clinical and radiographic tests of fusion of the hip. If the hip is firmly fused, and provided the sedimentation rate is below 25 millimetres in the first hour, the patient is allowed to walk in a double hip spica. After a further three months the plaster is discarded and the patient is allowed to go home. But he must be kept under careful supervision, and must return for routine examination every three months for at least a year, and thereafter at less frequent intervals.

SUMMARY

1. The anatomical and physiological principles underlying the operation of ischio-femoral arthrodesis by an anterior approach are discussed.
2. The technique of the operation is described.

The writer wishes to express his thanks to the Director of Medical Services, Kenya, for permission to publish this article, and to Mr G. Hermges for taking the coloured photographs.

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OPEN OPERATION FOR CONGENITAL DISLOCATION OF THE HIP

Results in Forty-four Cases (Fifty Hip Joints)

EIVIND PLATOU, OSLO, NORWAY

In a review of cases of congenital dislocation of the hip treated at the Orthopaedic Clinic in Oslo before 1934 there were nineteen in which redislocation had occurred; in only three of them was a satisfactory result obtained by further closed reduction and plaster fixation. During recent years we have come to favour operative treatment in cases of a certain type, and experience elsewhere points in the same direction.

OPEN REDUCTION

Open reduction of congenital dislocation of the hip is indicated when: 1) closed reduction cannot be achieved by an experienced surgeon within half an hour; 2) the head is displaced too far outwards, or where redislocation occurs readily on manipulation without a marked slip of the head of the femur; and 3) redislocation occurs during plaster fixation or subsequently, provided that technical errors have been avoided.

Manipulative reduction is attempted with the patient under deep anaesthesia. If reduction has not been achieved within half an hour, a plaster is applied with the hip in the best possible position as shown by control radiographs. Two weeks later open reduction is performed. The hip joint is exposed by Smith-Petersen's method and in about half the cases there is no need to divide the rectus tendon. The capsule is opened by a wide cruciate incision and the obstruction removed so that the head of the femur can be replaced in the socket. The acetabulum itself is left intact. Before closure 100,000 units of penicillin are dusted into the wound; the position is checked radiographically. Plaster is applied with the hip in full extension and abducted about 50 degrees. The best rotational position depends upon the extent of anteversion of the neck of the femur. The normal angle of anteversion is about 20 degrees and a corresponding amount of medial rotation is therefore appropriate. But when anteversion is very marked, fixation in 60–90 degrees of medial rotation may be required. In such cases rotation osteotomy should be performed about four to eight weeks after reduction.

Two months after operative reduction the plaster is removed and the child placed in a moulded plaster bed; internal rotation is maintained but the abduction is reduced to 30 degrees. The child is removed from the bed daily for massage and gentle mobilisation of the hip, but otherwise remains in the bed for one to two months. If position is maintained the child is then allowed to use a tricycle for a month and begins to walk four to five months after operation

This favourable progress is by no means invariable. Radiographs may reveal an alteration in the position of the femoral head with the result that further changes of plaster and more prolonged immobilisation become necessary. A shelf operation or rotation osteotomy may be needed (the indications for their employment will be considered later); thus the treatment may be prolonged by weeks or months.

CLINICAL REVIEW

During the period 1935–47, open reduction of fifty hip joints was performed in forty-four patients, thirty-eight of them girls, and six boys. Their average age was two years and nine months, actual ages varying from thirteen months to five years (Table I).

The frequency with which various structures prevented reduction was as follows: isthmus—twenty-one cases; ligamentum teres—five cases; isthmus+ligamentum teres—four cases; superior capsular fold—three cases; inferior capsular fold—ten cases; capsular fold+ligamentum teres—three cases; acetabular connective tissue—four cases. In some cases the head of the femur seemed to be too large for the acetabulum.

TABLE I
OPEN REDUCTION OF FIFTY HIP JOINTS

BILATERAL DISLOCATION:	Twenty patients. Bilateral open reduction in six; one side only—fourteen.
UNILATERAL DISLOCATION:	Twenty-four patients.

When an isthmus alone obstructed reduction, incision of the capsule was usually sufficient to permit reduction. When only a large ligamentum teres (up to a diameter of half a centimetre) prevented reduction, its removal was all that was needed. When one or other of the soft structures of the joint encroached upon the acetabulum it was often difficult to detach the capsule or to excise a pad of fibrous tissue without causing damage to the cartilaginous surface. This was especially so if the abnormal structure was situated inferiorly and posteriorly; in attacking it brisk haemorrhage was sometimes encountered. Sometimes perfect reduction was not achieved; the head was too large for the acetabulum and could not be entirely replaced under its upper lip. In such cases the question arises as to whether a shelf operation should be performed.

Results (Figs. 1 to 18)—Our patients are scattered throughout the country and consequently personal re-examination of all of them has not been possible. However, we have tried to obtain information by means of questionnaires, one completed by the parents and the other by the radiologist. Two patients (three open reductions) could not be traced and have been excluded from the tables.

The series has been divided into three groups according to the clinical results. The result was classed as *excellent* when there was complete freedom from symptoms referable to the hip; it was *good* when there were mild symptoms such as slight limping or a little pain on heavy exertion, but no other interference with normal activity; it was *poor* when there was an obvious limp, constant pain, and disability from the joint sufficient to affect daily life. The cases have also been grouped according to the radiographic findings. Thus *cured* indicates appearances approaching normal; a *good anatomical result* indicates moderate deformation of the head or neck of the femur, or of the acetabulum, perhaps with slight upward displacement of the head but no subluxation; considerable bone deformity, subluxation or redislocation is described as a *poor result*.

The results at the time of discharge from hospital are shown in Table II. Good clinical and radiological results were obtained in forty-one and thirty-nine instances respectively. The late results, however, were not so satisfactory (Tables III to VII).

TABLE II
RESULTS AT TIME OF DISCHARGE FROM HOSPITAL
(Fifty Cases)

CLINICAL	Excellent	25	41
	Good	16	
	Poor	9	
MOBILITY	Free	12	38
	Slightly reduced	26	
	Markedly reduced	12	
RADIOLOGICAL	Cured	21	39
	Good	18	
	Poor	11	

TABLE III

RESULTS 1–3 YEARS AFTER OPERATION
(Nineteen Cases)

		AT DISCHARGE		1–3 YEARS AFTER OPERATION	
CLINICAL	Excellent	11	17	15	17
	Good	6		2	
	Poor	2		2	
RADIOLOGICAL	Excellent	7	16	6	16
	Good	9		10	
	Poor	3		3	

Conclusion—no significant change

TABLE IV

RESULTS 3–5 YEARS AFTER OPERATION
(Five Cases)

		AT DISCHARGE	3–5 YEARS AFTER OPERATION
CLINICAL	Excellent	1	1
	Good	–	–
	Poor	4	4
RADIOLOGICAL	Excellent	1	1
	Good	–	–
	Poor	4	4

Conclusion—no change

TABLE V

RESULTS 5–10 YEARS AFTER OPERATION
(Seven Cases)

		AT DISCHARGE		5–10 YEARS AFTER OPERATION	
CLINICAL	Execllent	2	5	1	4
	Good	3		3	
	Poor	2		3	
RADIOLOGICAL	Excellent	2	6	–	2
	Good	4		2	
	Poor	1		5	

Conclusion—some deterioration

TABLE VI

RESULTS 10–13 YEARS AFTER OPERATION
(Sixteen Cases)

		AT DISCHARGE		10–13 YEARS AFTER OPERATION	
CLINICAL	Excellent	11	15	4	9*
	Good	4		5	
	Poor	1		7	
RADIOLOGICAL	Excellent	9	13	2	4*
	Good	4		2	
	Poor	3		12	

Conclusion—pronounced deterioration

* Two patients (three hips) not traced.

TABLE VII

SUMMARY OF THE WHOLE SERIES

		AT DISCHARGE		1–13 YEARS AFTER OPERATION	
CLINICAL	Excellent	25	38	21	31
	Good	13		10	
	Poor	9		16	
RADIOLOGICAL	Excellent	21	36	9	23
	Good	15		14	
	Poor	11		24	

Examination of the tables shows that there is a considerable falling off in the quality of the results. The group of cases with an observation period between ten and fifteen years has not been assessed at regular intervals and it is not possible to say when deterioration became noticeable.

Other observations—*The range of movement* in the hip was greatly reduced in twelve patients at the time of their discharge from hospital. However, among all the cases assessed between one to fifteen years later there was only one in which limitation of movement was disabling. It has been suggested that a small or absent centre of ossification in the head of the femur is a bad prognostic sign. In our series the presence or absence of the centre at the time of open reduction had no prognostic significance whatever.

Radiographs frequently show a *sloping acetabular roof*, but the degree of slope (which can be expressed numerically) has no relation to the prognosis and is not in itself an indication for a shelf operation. A steep acetabular roof was found in sixteen cases, and a very steep one in twenty-one; the corresponding clinical results are shown in Table VIII.

TABLE VIII

RESULTS IN RELATION TO SLOPE OF ACETABULAR ROOF

SLOPE OF ROOF	CASES	RESULT	CASES
Steep	16	Good	9
		Poor	7
Very steep	27	Good	19
		Poor	8

At open operation the surgeon usually finds that the condition of the acetabulum is far better than the radiograph suggests, especially in children below the age of two years when the greater part of the roof is composed of cartilage.

SHELF OPERATION

A shelf operation was performed on twelve occasions; simultaneously with the open reduction in five instances, with four good results; in another five, six weeks to two and a half years after the open reduction, with only one good result; and in two cases a shelf operation performed after closed reduction subsequently proved unsatisfactory, open reduction being required four months and one year and a half later respectively. The chief indication for the operation is a disproportionately large femoral head. The author considers that it should be employed more frequently than it has been in the past.

FIG. 1

FIG. 2

FIG. 3

Case 1 S. C. Age 3½ years. Figure 1—Closed reduction was unsuccessful. Open reduction: *right,* June 1936; *left,* August 1936. Figure 2—One year later. Acetabula still defective. Figure 3—Ten years later. Excellent anatomical and functional result.

FIG. 4

FIG. 5

FIG. 6

FIG. 7

Case 2 S. S. Age 3½ years. Figure 4—Closed reduction, left hip; open reduction, right hip (1936). Figure 5—Satisfactory position after operation. Figure 6—One year later. Figure 7—Twelve years later. Failure probably due to uncorrected anteversion.

FIG. 8

FIG. 9

FIG. 10

FIG. 11

Case 3 K. N. Age 2½ years. Figure 8—Radiograph on admission to hospital. Closed reduction was attempted. Figure 9—Eight months after closed reduction and fixation in plaster. Redisplacement has occurred. Open reduction advised. Figure 10—Two months after open reduction. Figure 11—Ten years after operation. Acetabulum is still shallow and head a little high. Clinically normal.

FIG. 12

FIG. 13

FIG. 14

FIG. 15

Case 4 L. R. Age 2¼ years. Figure 12—Displacement recurred after closed reduction. Open reduction undertaken. Figure 13—Three and a half years after operation. Defective ossification of head, and recurrence of subluxation owing to anteversion. Figure 14—Same time interval as Figure 13. Note that the head is in good position with limb medially rotated 60 degrees. Rotation osteotomy performed. Figure 15—Four years after osteotomy.

FIG. 16

FIG. 17

FIG. 18

A. G. Age 4¾ years. Figure 16—Poor acetabulum. Shelf operation clearly indicated. Figure 17—Six months after closed reduction and shelf operation. Displacement has recurred. Figure 18—Cause found to be imperfect reduction. At operative reduction a large ligamentum teres and a fibrous mass were found interposed between the joint surfaces. Satisfactory position two years after open reduction and reconstruction of acetabulum. **Case 5**

ROTATION OSTEOTOMY

This operation has been performed on a number of occasions in cases treated by manual reduction. The first osteotomy was done in 1937, the femur being divided at its mid-point; this is anatomically incorrect and the result was unsatisfactory. If rotation osteotomy is indicated after open reduction it should be performed four to eight weeks later. After complete fixation in plaster for eight weeks the child is placed in a moulded plaster bed, and movements and massage are started. The technique used by the author is to divide the femur with a saw just below the lesser trochanter and rotate the lower fragment outwards 60–80 degrees, as required, the position being maintained by means of a Lane's plate. Rotation osteotomy has been performed four times after open reduction with two satisfactory results. One poor result was due to the screw losing its hold in the porotic bone and allowing the lower fragment then to rotate back into its original position. There were ten cases of marked anteversion in which no operation was performed. In five the result was good; in five it was poor and these patients would, no doubt, have been benefited by osteotomy.

COMPLICATIONS OF OPEN OPERATIONS FOR CONGENITAL DISLOCATION OF THE HIP

There were no deaths, but serious post-operative collapse occurred in two cases. In another patient scarlatina with a severe wound infection developed on the fifth day after operation and the final result was unsatisfactory. In two other cases superficial infection occurred, which—although it complicated and prolonged the after-treatment—did not prevent good ultimate results. Fracture of the femur occurred in nine instances and of the tibia in two. Sciatic paralysis was observed in one patient but cleared up completely within three months. Twice there were recurrences of the dislocation while the patient was in plaster; one was in the patient with scarlatina; with the other, two further attempts at reduction were unsuccessful.

SUMMARY

1. The indications for open reduction in congenital dislocation of the hip are discussed.
2. The technique of the operation and the post-operative treatment are briefly described.
3. The results of the operation in fifty hips are presented.
4. The function and the radiographic appearances of the hip were usually good in the early years after open reduction, but there was a marked tendency to deterioration ten to thirteen years afterwards.
5. The indications for the shelf operation and for rotation osteotomy after open reduction are discussed.

JOHN HUNTER'S SPECIMEN OF TALOCALCANEAL BRIDGE

R. I. Harris and T. Beath, Toronto, Canada

In 1948 we called attention to talocalcaneal bridge (synostosis talocalcanea) as a cause of rigid flat foot, which until then had been unrecognised as a clinical entity.[1] Since the publication of this paper there has been ample confirmation of the accuracy of our observation from the experiences reported to us by our colleagues and from our own further investigations. Though orthopaedic surgeons have only now come to recognise the existence of this anomaly, and to appreciate its importance in the etiology of certain cases of peroneal spastic flat foot, anatomists have long been aware of it. We have discovered recently, in the Pathological

Fig. 1

Specimens prepared by John Hunter, and now mounted together under the number S.84.26.

Museum of the Royal College of Surgeons of England, a magnificent example of this anomaly. It is worth recording not only because it is one of John Hunter's original preparations but because it is the most perfect specimen we have yet seen. The specimen consists of the talus and calcaneus from the right and left feet of the same individual (Fig. 1). In each, the talus is united to the calcaneus by a plate of bone which extends backwards from the sustentaculum. The anomaly is precisely similar in each pair of bones.

Hunter's notes on the specimens have not survived and there is no means of knowing their source. It would seem a fair presumption that they came from a dissecting room cadaver. The notes that are available are in the first printed catalogue of the Hunterian Museum: "1884—A right astragalus and os calcis, firmly and smoothly united by a thin plate of bone laid over the inner margin of their inner and anterior articulation. 1885—The left astragalus and os calcis of the same person united in exactly the same manner."

We are much indebted to the College and to Dr L. W. Proger, the Pathological Curator, for permission to publish this note.

[1] Harris, R. I., and Beath, T. (1948); Etiology of Peroneal Spastic Flat Foot. Journal of Bone and Joint Surgery, **30-B**, 624.

TARSO-EPIPHYSIAL ACLASIS

A Congenital Error of Epiphysial Development

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This condition is a congenital growth disorder of the tarsus and of the epiphyses. So far as can be ascertained from perusal of the literature it was first described by Mouchet and Belot in 1926 in the case of a small boy, aged eighteen months, whose ankle was affected; they called it *tarsomégalie*. The disorder is more widespread than these authors appreciated and for that reason the term *tarsomégalie*, although descriptive enough of their own case, is not suitable when applied to the disorder as we now know it.

This contribution includes a clinical and radiological study with, in some cases, a report of the operative findings in eight patients suffering from tarso-epiphysial aclasis. Seven of the patients were boys and one was a girl; the youngest was first seen at the age of nine months and the oldest at ten years. The lower limbs alone were affected, the left five times and the right three times.

Distribution—The site generally involved was the knee or ankle joint—both knee and ankle together in five patients, the knee joint alone in two and the ankle joint alone in one. When there was change in both knee and ankle joints it was invariably found that the same side of the epiphyses was affected in both joints—the inner side of the knee with the inner side of the ankle, or the outer side of the knee with the outer side of the ankle. There was no instance of the inner side of the knee joint being involved with the outer side of the ankle, or vice versa. Of the seven patients with involvement of the knee joint, the medial condyle of the femur was affected in five (two with similar change in the medial half of the upper tibial epiphysis) and the lateral femoral condyle in two (one with similar change in the lateral half of the upper tibial epiphysis). Of the seven patients with involvement of the ankle joint the medial malleolus and medial half of the talus was affected in four (two with changes also in the tarsal navicular and cuneiform bones), and the lateral malleolus and lateral half of the talus in three. In one patient the medial half of the upper femoral epiphysis was affected.

Clinical features—Medical advice was sought either by reason of deformity of the lower limb or of swelling in the region of the knee or ankle joints. There was no complaint of pain. The deformity depended upon the site of the lesion. Affection of the medial epiphyses of the knee joint caused genu valgum—one patient aged less than five years having four and a half inches of deformity, partly in the femur and partly in the tibia (Case 4). Affection of the lateral part of the lower femoral or upper tibial epiphyses caused genu varum. It was the bony mass from overgrowth of the epiphyses that accounted for deformity and also interfered with full movement of the joint (there being limitation of both flexion and extension movement in Case 4, of flexion movement alone in Case 5 and of extension movement alone in Case 8). Similarly, a bony mass on the medial side of the ankle joint caused severe valgus deformity with limitation of inversion movement, while involvement of the lateral aspect of the ankle joint caused varus deformity. The circumference of the limb was sometimes smaller than on the normal side, but there was no true shortening. Such investigations as the Wassermann reaction and the blood count showed no departure from the normal.

Radiographic appearances—These are both striking and characteristic. The changes are confined to the epiphyses; the metaphysis is normal. In the case of the knee joint there is

enlargement of the femoral epiphysis, and sometimes of the tibial epiphysis (Cases **4**, **5** and **6**). This enlargement grows from the epiphysis back towards the popliteal space above the epiphysial line, extending also inwards on the medial side and outwards on the lateral side. The appearances suggest a mass of cartilage tissue in which there are several foci of ossification. This is well illustrated in the youngest child (Case **8**). In older children the separate foci have fused, thus giving rise to a more uniform appearance throughout the growth. The changes are seen in only half of the epiphysis: in two cases the medial half of the femoral epiphysis was affected anteriorly and the corresponding half of the tibial epiphysis was affected posteriorly. When the medial side of the ankle was affected the medial malleolus was enlarged, and on the medial side of the talus there was a surface growth extending medially, irregular in outline and similar to (but not so well defined as) the knee outgrowth. The whole talus was irregular and enlarged—sometimes twice the size of that on the opposite side and as big as the calcaneum. When the navicular and the cuneiforms were affected, singly or

FIG. 1

FIG. 2

Case 1. Figure 1—Right ankle showing enlargement of the lateral malleolus extending down to the talus; and Figure 2, enlargement of the medial malleolus and the lateral side of the talus with an irregular outgrowth from each.

together, the ossific nucleus appeared early; instead of one centre there were several small foci. When the lesion occurred in the lateral side of the ankle the radiographic changes were similar.

In Case **7** of this series the upper femoral epiphysis was irregularly enlarged, mainly on the medial side; this is especially interesting because the medial side of the lower femoral epiphysis, the medial side of the upper tibial epiphysis, the medial malleolus, the medial half of the talus, the navicular and cuneiforms were involved; this distribution may be of significance in considering the etiology of the condition.

The bony enlargements were observed macroscopically in the patients submitted to operation. In Case **1** the swelling on the outer side of the ankle consisted of a pedunculated "exostosis" about one inch in length, with smaller distinct nodules, some on the anterior margin of the lower end of the tibia; the part removed consisted largely of bone covered by cartilage, the surface of which was nodular. In Case **2** the swelling was smooth, rounded and attached to the medial femoral condyle by a wide, short pedicle. It consisted of cartilage with a few bony nuclei in its substance. In Case **4** the medial femoral condyle was enlarged, nodular and bluish in places; no distinction could be made between the swelling and the

medial femoral condyle except at its lateral margin in the intercondylar notch; the appearances of the adjacent portion of the upper end of the tibia were similar. When later the ankle region was explored a grossly nodular bony swelling was removed from the lower end of the medial side of the tibia; the upper and medial sides of the talus were similarly nodulated. In Case 6 the lateral femoral condyle was enlarged; the epiphysial cartilage seemed normal except for many small nodules. In Case 8 (the youngest child in the series) the medial femoral condyle was enlarged but smooth.

In Cases 1, 2, 4 and 6 a part of the bony enlargement was examined microscopically; all the sections showed normal hyaline cartilage with areas of ossification.

CASE REPORTS

Case 1. (Reported by the courtesy of Sir Thomas Fairbank. Figures 1 and 2.) Boy aged ten years. Had noticed swelling of the right ankle for two years; the foot had begun to "turn over." On examination there was varus deformity of the right ankle, with a bony enlargement of the lateral malleolus and of the talus. The foot could not be everted. The right thigh and calf were smaller in circumference than the left. The only other abnormality found on general examination was a cataract of the right eye. Radiographs confirmed that the bony enlargement extended from the lateral malleolus and that the lateral sides of the talus and calcaneum were also involved. The enlargement was removed.

FIG. 3
Case 2. Left knee showing enlargement of the medial half of the lower femoral epiphysis. There are several foci of ossification.

Case 2. (Reported by the courtesy of Sir Thomas Fairbank. Figure 3.) Boy aged four and a half years. For six weeks there had been a painless swelling on the inner side of the left knee; movement was full and painless. The swelling appeared to arise from the medial femoral condyle; this was confirmed by radiographic examination. The bony prominence was excised. Subsequent radiographs suggested some persistent bony nodules on the surface of the condyle, but a further exploration, more posteriorly, showed only a smooth cartilaginous convexity. When this patient was examined recently, many years after the operation, the function of the knee joint was normal.

Case 3. (Reported by the courtesy of Sir Reginald Watson-Jones. Figures 4, 5 and 6.) Boy aged eight years. Advice was sought for a swelling on the lateral side of the right knee. The boy was stated to have fallen on the knee from a chair at the age of fifteen months, and later to have injured the same knee in falling from his brother's back. On examination there was a bony swelling at the lateral side of the lateral femoral condyle. The movements of the knee joint were normal except for excessive rotation of the extended joint. There was a similar bony mass below and behind the lateral malleolus. The movements of the ankle joint were limited to 20 degrees but were painless. There was marked varus deformity of the foot, and bowing of the right tibia.

Case 4. (Reported by the courtesy of Miss M. Forrester-Brown. Figures 7 and 8.) Boy aged four and a half years when first seen. Left genu valgum noticed at the age of two years. The deformity had increased gradually. On examination there was enlargement of the medial femoral condyle and tibial tuberosity. There was marked valgus deformity, with four and a half inches separation between the malleoli. The knee joint was held flexed;

FIG. 4

FIG. 5

FIG. 6

Case 3. Figure 4—Knee showing an enlargement of the lateral femoral condyle. Figures 5 and 6 are anterior and lateral views showing a cartilaginous-bony mass extending from the lateral half of the talus below and behind the lateral malleolus.

FIG. 7

FIG. 8

Case 4. Figure 7—Enlargement of the medial malleolus and medial half of the talus causing a valgus deformity. Figure 8 is a lateral view of the ankle showing that the mass is extending from the medial side of the talus anteriorly and posteriorly to the medial malleolus.

FIG. 9

FIG. 10

FIG. 11

Case 5. Figures 9 and 10—Left knee showing enlargement of the medial femoral condyle and of the medial half of the upper tibial epiphysis. The swelling extends medially and backwards towards the popliteal space and has caused genu valgum. Figure 11 shows enlargement of the left medial malleolus and irregular bony outgrowth extending downwards towards the talus. This enlargement caused a valgus deformity.

extension and flexion were limited; the total range of movement was approximately 60 degrees. Radiographs confirmed the clinical findings and showed also a small amount of backward subluxation of the tibia on the femur. Excision of the bony mass with arthrodesis of the knee was undertaken. Later examination showed an extreme valgus deformity of the left foot, and great restriction of ankle joint movements. Gross enlargement of the medial malleolus was found. At operation the talus was found to be involved extensively. The bony enlargements of the malleolus and talus were excised. Fifteen years later the patient was "looking well and walking well; he seems to have been earning his living for years."

Case 5. (Under the care of the author. Figures 9, 10 and 11.) Boy aged seven years. Valgus deformity of the left foot and knee. On examination there was genu valgum with three inches separation of the malleoli. There was limitation of flexion of the knee joint, caused by a hard bony swelling which extended backwards from the medial side of the knee into the popliteal fossa. It was considered that this enlargement was the cause of the genu valgum. There was a similar but smaller swelling of the medial malleolus of the left ankle. There was a full range of movement of the ankle joint but inversion of the foot was restricted by the bony swelling. Radiographs confirmed the clinical findings. Operation was not advised, but valgus wedges were fitted to the left shoe. Three and a half years later the condition of the limb was unchanged. Disability was slight and the patient was leading a normal life.

FIG. 12 FIG. 13

Case 6. Figure 12—Enlargement of the lateral condyle of the femur with enlargement of the corresponding half of the upper tibial epiphysis. The enlargement of the femoral condyle has occurred mainly in an anterior direction; that of the tibial epiphysis extends postero-laterally. The unilateral enlargements of the bone caused genu varum. Figure 13—Enlargement of the lateral malleolus and of the lateral part of the talus; the malleolar enlargement, which has several points of ossification, extends downwards and backwards.

Case 6. (Reported by the courtesy of Mr Sayle Creer. Figures 12 and 13.) Boy aged one and a half years when first seen. Parents noticed that he was walking badly, dragging his left leg and falling frequently. At that time a lateral curvature of the left tibia was noted. Six months later a swelling was noticed on the lateral side of the left knee. Radiographs showed a bony mass projecting from the lateral half of the lateral femoral condyle and from the tibial tuberosity.

The swelling was explored at operation. There was enlargement of the femoral condyle, which had many small nodules on its surface. The mass was not removed, but a small piece was taken for microscopic examination. Histologically it was composed of normal ossifying

cartilage. A caliper was prescribed. When seen eight months later the lateral curvature of the left tibia had increased; movements of the knee joint were restricted to a range from 150–60 degrees. Two years later there had been no further increase of the deformity. The boy was leading an active life, complained only of an occasional ache in the knee, and extension movement had increased to within 5 degrees of the full range. No further treatment was recommended. Later examination of his left ankle showed a similar enlargement of the lateral side. The swelling was symptomless and did not interfere with function.

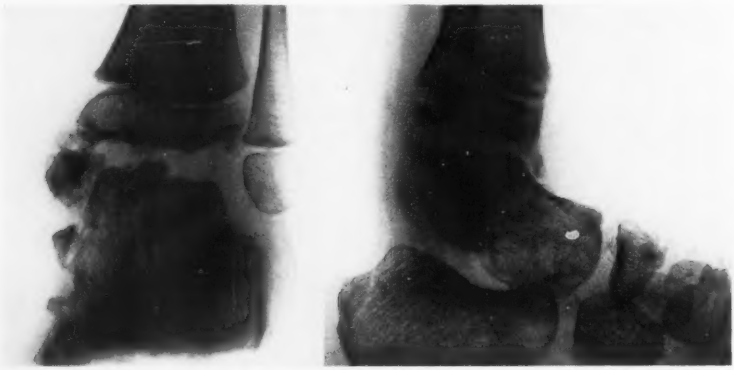

FIG. 14

FIG. 15

Case 7. Figure 14—Enlargement of the medial malleolus and of the medial half of the talus, which is almost as large as the calcaneum. The navicular also is enlarged and there are several foci of ossification in the region of the medial cuneiform. Figure 15—Irregularity of the medial half of the left femoral head.

Case 7. (Reported by the courtesy of Mr Norman Capener. Figures 14 and 15.) Boy aged three years when first seen. Valgus deformity of the left foot, and no other symptoms. On examination there was enlargement of the medial malleolus of the left tibia. Radiographs showed enlargement of the medial half of the tibial epiphysis extending into the medial malleolus, which was increased in size and extended downwards towards the talus. The talus was enlarged, and an irregular bony outgrowth projected from its medial surface and from the medial half of its superior surface. The navicular and medial cuneiform

presented similar appearances. Further radiographs showed enlargement of the medial femoral condyle and of the medial half of the femoral head. No other bones were affected.

When this boy was examined recently the condition of the left foot and ankle remained unchanged; there was a small enlargement of the medial femoral condyle but this did not interfere with the function of the knee joint and caused no deformity. The lower limbs were of equal length and girth. The boy was leading an active life, without disability. He was advised to wear valgus heel wedges but no other treatment was considered necessary.

Case 8. (Reported by the courtesy of Mr E. S. Evans. Figures 16 and 17.) Girl aged nine months when first seen. Mother had noticed that the child was unable to extend the right knee fully and that the right foot was deformed. On examination there was severe genu valgum and limitation of extension of the right knee. There was also gross valgus deformity of the right foot, but this could be corrected manually. Radiographs showed a bony outgrowth

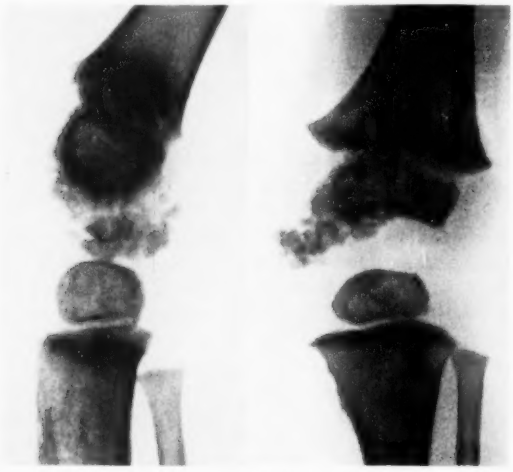

FIG. 16

FIG. 17

Case 8. Figure 16—Enlargement of the medial femoral condyle. The cartilaginous-bony mass extends downwards, medially and backwards; there are several foci of ossification. Note the irregularity of the outline of the tibial shaft on the medial side in the region of the metaphysis. Figure 17—Right foot. Note the irregularity of the medial side of the talus and its enlargement, the multiple foci of ossification of the navicular and the early appearance of the ossific nuclei of the medial and middle cuneiforms.

from the medial femoral condyle with a mottled appearance due to multiple foci of ossification. The talus was enlarged and irregular outgrowths projected from its surface. The ossific centre for the navicular had appeared early and consisted of several separated foci; the ossific centres for the medial and middle cuneiform bones had also appeared prematurely.

Exploration of the medial side of the knee joint was undertaken at the age of two years. The medial femoral condyle was enlarged and smooth, but excision of the excess bone was not considered necessary. Supracondylar osteotomy was performed to correct the genu valgum. A lateral iron and medial T-strap were fitted to control the severe valgus deformity of the foot.

DIAGNOSIS

Tarso-epiphysial aclasis is clinically distinct from dyschondroplasia and from diaphysial aclasis, and no confusion should arise. Radiologically the distinction is obvious, for in dyschondroplasia and in diaphysial aclasis the essential changes are found in the metaphysis.

Dysplasia epiphysialis punctata, although easily distinguished clinically, may be confused with tarso-epiphysial aclasis radiographically. In dysplasia epiphysialis punctata, particularly when the tarsus is involved, the stippling effect occurs in the epiphysis and extends throughout its whole width; the shafts of the long bones may be thickened and shortened and the metaphysis splayed. In tarso-epiphysial aclasis the stippling effect arises from the epiphysis and, in the case of the epiphyses of the long bones, from one half only; and the metaphysis appears normal.

ETIOLOGY

The condition is considered to be a congenital error of skeletal development. In the distribution of the lesions it resembles melorheostosis where one side of a limb is involved; in no case of this series was the medial side of the knee affected with the lateral side of the ankle and vice versa. It is suggested that the etiological factor affects the limb buds during early foetal life. This would explain the distribution: a pre-axial affection would produce the deformity on the medial side of the limb and a post-axial affection on the lateral side.

The arrangement of the blood vessels in the epiphyses (Fig. 18) may explain why the condition is confined to one half of the epiphysis. It may explain also the several foci of ossification that occur in the cartilaginous mass as it grows away from the epiphysis. According to Harris (1933) the cartilage of an epiphysis of a long bone is formed from a narrow zone where cartilage cells are actively dividing—a zone which he calls the mitotic annulus. At the centre of the cartilage mass, bony trabeculae of the ossific nucleus are produced. Surrounding this is a zone where degenerate cartilage cells are arranged in columns within a calcified matrix. And between this zone and the mitotic annulus there is a mass of cartilage cells, the youngest cells being adjacent to the mitotic annulus. The same arrangement occurs at the epiphysial line—successive zones extending from the mitotic annulus towards the shaft of a long bone consist first of young cells, older cells, and then degenerate cartilage cells arranged in columns with a calcified matrix, and lastly, diaphysial bone. But the arrangement of the cells between the mitotic annulus and the articular surface of the epiphysis is different. Adjacent to the mitotic annulus are the young, recently formed cartilage cells; next are older cells more widely separated and flatter in outline; and at the articular surface the cells are completely flat and senescent. They eventually disintegrate and together with the matrix give rise to the main constituent of synovial fluid (Fig. 19). It is suggested that in tarso-epiphysial aclasis the process is altered and that the cells do not become senile and flat but retain their power of division, so that a mass of cartilage is produced. Later, calcification of the matrix occurs in discrete areas, which become ossified. Radiographically these are seen as multiple foci of ossification.

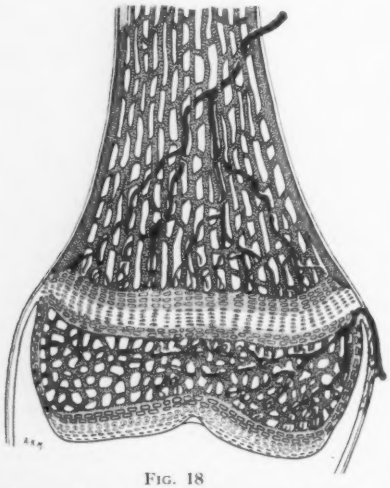

FIG. 18

Diagram showing arrangement of blood vessels supplying the epiphysis and metaphysis in the lower end of the femur (*from* Harris).

It is probable that the pathology is the same in the case of the tarsus. The mitotic annulus produces cells on its central aspect which form the main cartilage mass of the bone, and the ossific nucleus forms within it. The cells produced peripherally normally become flattened and senile towards the surface, and finally disintegrate. Failure of these peripheral cells to degenerate in the normal way causes a mass of cartilage to grow from the

peripheral surface and accounts for the generalised enlargement of a bone such as the talus.

It is because of the failure to confine these peripheral cartilaginous cells, derived from the mitotic annulus, that the term tarso-epiphysial aclasis is suggested for this affection.

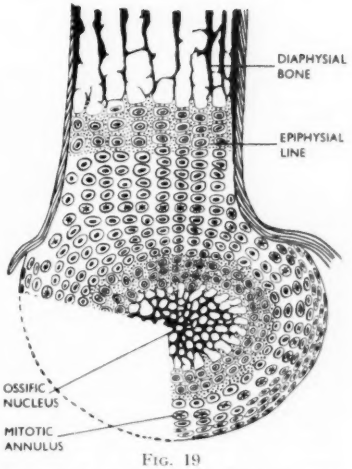

FIG. 19

Diagram showing mitotic annulus, ossific nucleus, diaphysial bone and epiphysial line (*from* Harris).

TREATMENT

If the projecting mass can be removed without causing instability of the affected joint it should be removed; in Cases 1 and 2 the swelling was of a localised character and its removal produced a satisfactory end-result. But when the outgrowth is extensive its complete excision may necessitate stabilisation of the joint. This should be undertaken only if it is fully justified by the severity of the disability, and is seldom necessary. In Case 5 there was excellent function despite a large outgrowth on the postero-medial aspect of the knee and a smaller outgrowth on the medial side of the ankle. When a large bony outgrowth is associated with marked genu valgum it is advisable to remove as much as possible of the swelling without impairing the stability of the knee joint, and to correct the residual deformity by osteotomy. The treatment of outgrowths around the ankle joint is along similar lines, but when the enlargement and deformity are severe and affect the talus the parents should be warned that arthrodesis of the ankle joint may become necessary in later childhood.

I wish to thank all those surgeons who have readily given me permission to use the notes and radiographs of patients under their care. I am grateful in particular to Sir Thomas Fairbank for his constant helpfulness, kindly criticism and stimulation. It was only through his untiring efforts that it was possible to collect the cases in this series. Figures 18 and 19 are taken from H. A. Harris's " Bone Growth in Health and Disease "; my thanks are due to Professor Harris and to the publisher (Oxford University Press).

AUTHOR'S POSTSCRIPT

Since this paper was submitted for publication, reports of two more patients afflicted with this condition have reached me through the kindness of Sir Thomas Fairbank. A six-year-old boy under the care of Mr R. H. Metcalfe had the inner side of the right ankle and foot involved; there was no functional disability, although he had to wear boots made to measure. The other patient is a four-year-old boy under the care of Mr Donald Brown of Newcastle-upon-Tyne; in this child, the medial *left* femoral condyle and the inner side of the *right* ankle and foot were affected. This is the only case of the series to show involvement of both lower limbs. Examination showed no other skeletal abnormality in either child. My thanks are due to Mr Metcalfe and to Mr Brown for permission to mention their cases.

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HALLUX RIGIDUS

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Patients with hallux rigidus are customarily classed into adolescent and adult groups according to the age at which symptoms first appear. Radiologists have called attention in adolescent cases to an appearance of increased density, sometimes of fragmentation, of the epiphysis of the proximal phalanx, and it has been claimed that these changes may have etiological significance. This paper describes a series of clinico-pathological studies undertaken by the authors to determine the nature of the alleged radiographic changes and to investigate the detailed pathology and etiology of hallux rigidus.

Clinical material—Thirty-three patients were studied. Eighteen were under twenty-five years of age (*adolescent group*) and fifteen were over twenty-five years of age (*adult group*). Twelve operation specimens of bone and joint tissue were examined histologically. A control series of fifty normal feet was studied radiologically; and specimens of healthy great-toe joints obtained at autopsy were sectioned.

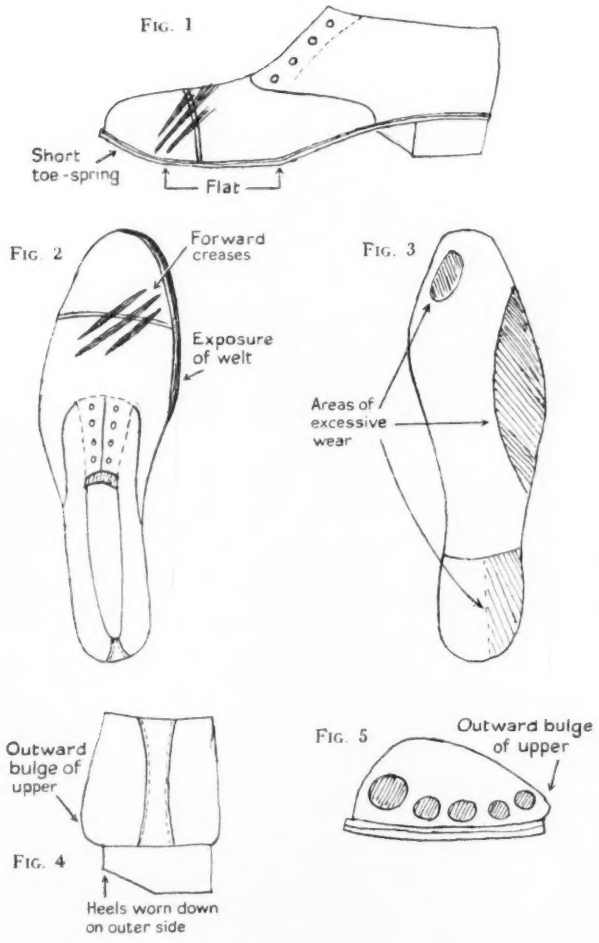
ANALYSIS OF IMPORTANT OBSERVATIONS

Clinical features—The youngest patient was ten years of age, the oldest sixty-two; the other cases were distributed fairly evenly between these extremes. In the adult group the two sexes were affected equally, but in the adolescent group seventeen of the eighteen patients were females. This great preponderance of females in the adolescent group is not easy to explain but may reflect the difficulty of obtaining satisfactory shoes for growing girls.

Symptoms—Pain of gradual onset in the great toe had been present variously between six weeks and nineteen years. In a few cases the pain had been precipitated by injury, but usually no cause could be remembered. The pain was described as constant, burning, throbbing or aching. It was relieved by rest and made worse by walking or sometimes by the warmth of the bed.

Signs—The metatarso-phalangeal joint was enlarged and tender, and often held in slight flexion. Active dorsiflexion was impossible and attempts to dorsiflex the toe passively were painful. Flexion was little impaired except in advanced cases in which the joint was completely rigid. Movements of the joint were often accompanied by crepitus. The skin beneath the metatarso-phalangeal joint was smooth, but a callosity usually covered the medial half of the pad of the great toe. A much larger callosity occurred under the heads of the second, third and fourth metatarsals. A third callosity was often seen on the outer border of the heel. Occasionally a large exostosis on the dorsum of the first metatarsal head was covered by a bursa giving rise to a painful dorsal bunion.

The interphalangeal joint was always hypermobile in adolescents; as much as 60 to 70 degrees of passive dorsiflexion was often present. In adults the range of interphalangeal movement was sometimes diminished, and occasionally painful. In some patients spasm of the extensor hallucis longus raised a longitudinal fold of skin and pulled the terminal phalanx into hyperextension. The general shape of the feet was seldom normal. Hallux rigidus was usually associated with long, narrow, pronated feet with unstable arches. Other abnormalities included excessively long great toes, hypermobile or adducted first metatarsals, valgus heels due to shortening of the tendo Achillis, and short flexor hallucis longus tendons. There was usually some clawing of the outer four toes.



Figs. 1–5

Abnormal wear of shoes in hallux rigidus. In Figure 1 a right-foot shoe is seen from the inner side; all other sketches show left-foot shoes. Figure 5 is a cross-section made through the forepart.

Shoes were seldom wide enough and were often too short. Shape and wear were so typical that the diagnosis of hallux rigidus could often be made simply on a glance at the patient's shoes (Figs. 1 to 5). There was excessive wear on the outer side of the heel and posterior half of the sole, and under the terminal phalanx of the great toe. The tread was much nearer the front of the shoe than normal. The toe-spring was correspondingly shortened, and the upper bulged over the outer side of the heel and the posterior half of the sole. There were at least two creases across the vamp. One, at the level of the metatarso-phalangeal joints, crossed it completely. In front of this crease, and on the medial side only, there were one, two or three more, furrowing the toe-cap; these had been caused by the hypermobile interphalangeal joint of the great toe.

PATHOLOGY

The proximal epiphysis of the phalanx—Increased radiographic density of the proximal epiphysis of the phalanx (Fig. 6) was present in all cases in our adolescent group. Sometimes an irregular blotchy density was seen (Fig. 7) and occasionally the radiographs suggested fragmentation of the epiphysis (Fig. 8). Exactly similar changes were, however, seen in the clinically normal foot in unilateral cases; and in a control series of fifty unselected symptomless feet in patients of similar age attending the clinic for other reasons. In these patients, areas of relative translucence often have the appearance of fragmentation (Fig. 9).

To study the matter further, four healthy great-toe joints were removed at autopsy from children between the ages of six and fifteen years. The specimens were radiographed and then sectioned. In every case the phalangeal epiphysis appeared relatively opaque in

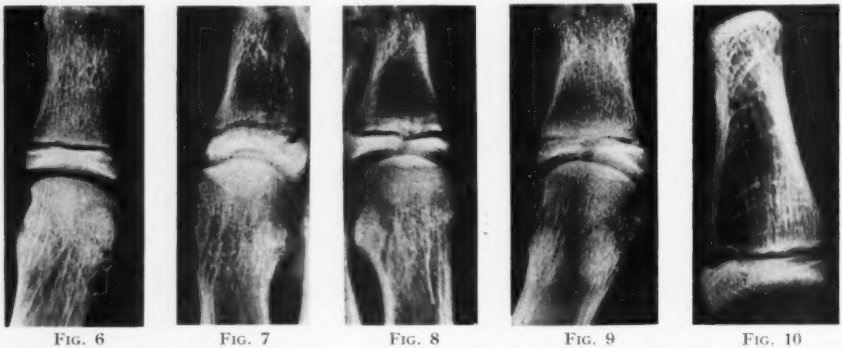


FIG. 6 FIG. 7 FIG. 8 FIG. 9 FIG. 10

Figure 6—Dense basal epiphysis of proximal phalanx of great toe. Left foot of girl, aged ten years, hallux rigidus for two years. Figure 7—Irregular density of basal epiphysis at first hallux joint. Right foot of girl aged twelve years, hallux rigidus for one year. Figure 8—Apparent fragmentation of basal epiphysis at first hallux joint. Left foot of girl aged eleven years, hallux rigidus for two years. Figure 9—Density and apparent fragmentation of basal epiphysis in a healthy foot. Left foot of girl aged twelve years, having normal feet and freely movable painless great-toe joints. Figure 10—Autopsy specimen of proximal phalanx of normal great toe, showing relatively increased density of epiphysial bone. (Male, aged fifteen years.)

the radiographs (Fig. 10). Histologically the bone of the epiphysis consisted of very broad trabeculae with small marrow spaces. The trabeculae, in contrast with those of the phalangeal shaft, were disposed more transversely across the long axis of the bone. In some of the larger bone masses the small vascular canals were surrounded by concentric rings of laminated bone, thus showing a pattern resembling compact or cortical bone. Occasionally a raphe of cellular fibrous tissue extended between the articular cartilage and the growth plate (Fig. 11), dividing the epiphysial bone into two or more parts and clearly indicating that ossification had taken place simultaneously from two or more secondary centres. A similar appearance of coarsely trabeculated, almost compact, bone in the epiphysis was observed in several phalangeal epiphyses removed at operation for adolescent hallux rigidus (Fig. 12). In no instance was there any evidence of avascular necrosis, bone dystrophy, fracture or inflammation.

The joint—Where the onset had been recent, examination at operation showed an increase in the fluid content of the joint. The fluid was clear and viscous, but the quantities were too small for analysis. Erosions of the articular cartilage at the centre and at the dorsal margin of the base of the phalanx were always found. Erosion of the corresponding area of the metatarsal head was seldom seen. Histologically the synovial membrane showed moderate synovial proliferation with congestion of the villi and a light lymphocytic infiltration (Fig. 13). The cartilage erosion and synovial changes were consistent with the reaction of the joint to

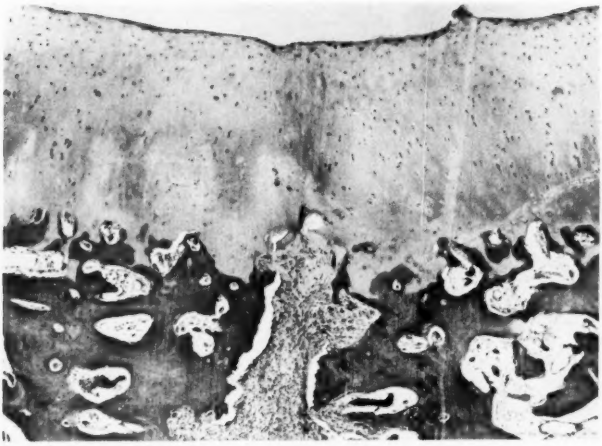


FIG. 11

Section of epiphysis and articular cartilage of normal great-toe proximal phalanx. (Autopsy specimen from male, aged fifteen years.) Articular cartilage is normal. Epiphysial bone is formed of broad and strong trabeculae whose general disposition is across the long axis of the bone. There is a median raphe of fibrous tissue which divides the epiphysial bone and has arisen from two centres of ossification. (H. & E., ×33 approx.)

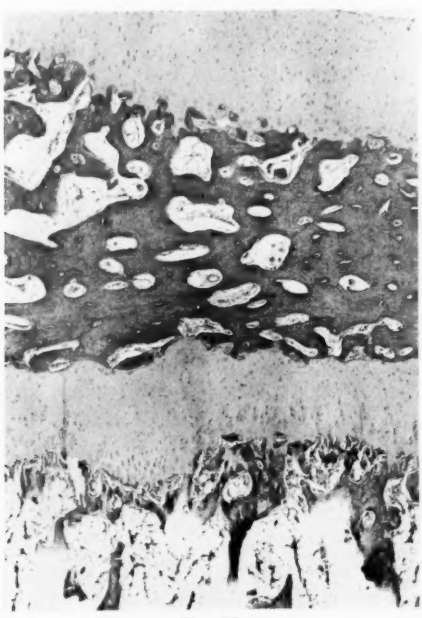


FIG. 12

Coarsely trabeculated, almost compact, bone of the basal epiphysis. Operation specimen from girl aged ten years (*cf.* radiograph in Figure 6). This is healthy bone of the structure normally seen in this epiphysis. Section shows articular cartilage (above), and epiphysial bone, healthy growth cartilage and metaphysis (below). (H. and E., ×18 approx.)

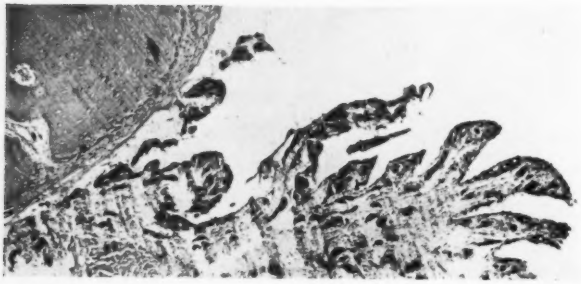


FIG. 13

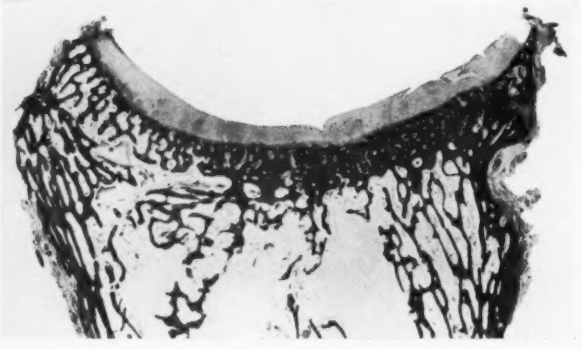
Figure 13—Synovial membrane in hallux rigidus. Moderate villous proliferation, vascular congestion and light lymphocytic infiltration of synovial tissues near reflection from metatarsal head. Traumatic synovitis. Early erosion of phalangeal cartilage was present. (Girl, aged twelve years.) (H. and E., ×40 approx.)

FIG. 14

Figure 14—Earliest radiographic evidence of osteoarthritis. Left foot of girl, aged fifteen years, with bilateral hallux rigidus. The basal epiphysis is almost united but still appears dense. The metatarsal head is becoming flattened and shows osteophytic lipping of the dorso-lateral margin.

Figure 15—Section of base of proximal phalanx of great toe. Male, aged twenty-one years, with three years' history of hallux rigidus. Osteoarthritis with cartilage erosion and fibrillation near centre and towards dorsal margin (right), and dorsal osteophyte. The sclerotic subchondral bone is the normally dense bone of the epiphysis which persists after epiphysial union. (H. and E., ×4½ approx.)

FIG. 15



chronic trauma. In adolescent patients we found no evidence of pre-existing arthritis of rheumatoid or infective type.

In cases of longer standing there was evidence of well-marked osteoarthritis. The earliest age at which radiographic evidence of osteoarthritis was present was fifteen years; deformity of the joint facets and marginal lipping can be seen in Figure 14. Histologically the appearances were those characteristic of osteoarthritis, which have been described recently by Collins (1949). There was an unusual amount of dense subchondral bone (Fig. 15), representing a survival of the original dense epiphysis rather than subchondral bone sclerosis reactive to destruction of the overlying cartilage. Loss of superficial cartilage layers, clumping of chondrocytes in the deeper layers and irregularity of the calcified line at the base of the articular cartilage were often seen (as in Fig. 16). Fibrillation of cartilage and irregular advance of ossification into the articular cartilage were also seen (Fig. 17), and marginal osteophytic spurs and shelves took the usual form.

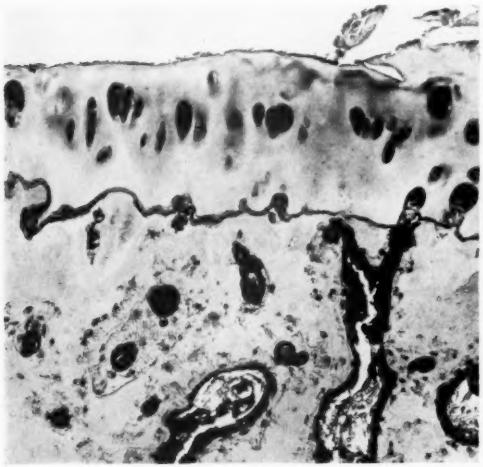


FIG. 16

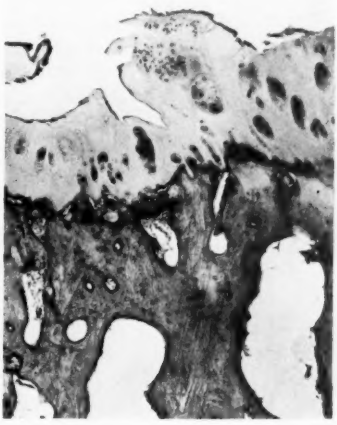


FIG. 17

Figure 16—Early osteoarthritis in hallux rigidus. Note loss of surface zones of articular cartilage, distorted calcified line in deep cartilage and density of subchondral bone. The marrow spaces, vascular canals and some bone canaliculi are outlined by the silver stain. (Gomori's silver nitrate method, ×31 approx.)
Figure 17—Osteoarthritis in hallux rigidus. Section of base of proximal phalanx with typical osteoarthritic changes, destruction and fibrillation of cartilage and irregularity of chondro-osseous junction. Male, aged forty-four years, with symptoms arising in adult life. (H. and E., ×27 approx.)

DISCUSSION

An appearance of increased density of the basal epiphysis of the proximal phalanx in adolescent hallux rigidus has led to much speculation about its significance. Hauser (1939) and Glissan (1946) considered that the radiographic appearances might represent an affection of the bone of a similar nature to Legg-Perthes disease of the hip and other forms of osteochondritis juvenilis, and they believed that these changes were of etiological significance. Brailsford (1948) stated that "pain in the big-toe joint with limitation of movement in the young person may be associated with increased density of the basal epihpysis. In some cases this is the forerunner of chronic arthritis of the joint. The dense epiphysis may appear to be split into two parts by a fissure in the mid-line. This may be seen in girls about the age of twelve years who complain of pain." Our studies of the morbid anatomy of hallux rigidus do not support the view that the radiographic appearance of density of the basal epiphysis

of the proximal phalanx is etiologically significant. The fact that similar changes are present in normal feet in adolescents suggests that the increased density does not represent any abnormality of the bone. In this connection a study of the development of the basal phalangeal epiphysis is of interest. The epiphysis appears as two or three tiny dots at the age of two to three years in girls and three to four years in boys. These centres coalesce to form a single centre of ossification within a year. At six years of age the epiphysis becomes denser than the adjoining bone and remains dense throughout the period of growth. It fuses with the shaft at thirteen to fourteen years in girls and fifteen to seventeen years in boys. After fusion has occurred the base of the phalanx retains its increased density in some degree throughout life. Similar inequalities in radiographic density have been observed in the calcaneal epiphysis and have been misinterpreted as pathological abnormalities. But Hughes (1948) has determined that the same appearance is seen in normal feet as well as in feet with painful heels, and Bergmann (1926) has shown histologically that the apparent increase in radiographic density is due to the closely packed but healthy trabeculae, which in this epiphysis also are disposed at 90 degrees to the general disposition of the trabeculae in the main part of the bone.

As to the nature of the pathological changes in hallux rigidus, our observations have led us to conclude: 1) that the earliest detectable pathological changes are traumatic synovitis and cartilage erosion; and 2) that osteoarthritis develops sooner or later and has the same characteristics as osteoarthritis occurring elsewhere in the body.

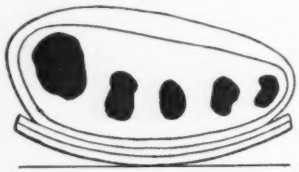


FIG. 18

Diagram showing how a boat-shaped sole elevates the first metatarsal and how the curvature of the transverse anterior arch of the foot becomes reversed.

The fact that gross osteoarthritis of the metatarso-phalangeal joint may arise early in life, usually without preceding injury, suggests that abnormal mechanical conditions may be an important etiological factor. We have investigated the nature of such mechanical abnormalities, and have formulated a hypothesis to explain the origin of hallux rigidus. We consider that hallux rigidus is due to an abnormal gait which so alters the dynamics of the foot that osteoarthritis develops in the joints of the great toe. The causes of the abnormal gait are pain or discomfort in the great toe and hypermobility of the first metatarsal.

Pain or discomfort in the great toe may arise from: 1) *Valgus deformity of the feet*: this is common in patients with hallux rigidus; most of the weight of the body is borne on the inner side of the foot, and excessive pressure acts on the proximal great-toe joint. 2) *Defective footwear*: shoes that are too short or too narrow predispose to repeated minor injuries or compression forces acting on the great toe; excessive length of the great toe may have similar effects. 3) *Injury to the joint of the hallux* by severe stubbing, by forcible hyperflexion or by dropping a weight on the toe. 4) *Damage to the joint* by rheumatoid arthritis or gout.

Hypermobility of the first metatarsal may be a developmental anomaly. But more often it seems to be caused by squeezing the foot into a shoe that is too narrow. In order to make such a thing possible, the manufacturer often designs shoes with the sole concave upwards. As a result, the first and fifth metatarsals are displaced dorsally and become hypermobile. The middle three metatarsals sink into the hollow of the sole (Fig. 18). The anterior metatarsal arch, normally concave downwards, becomes reversed. The first and fifth metatarsals cause the upper of the shoe to bulge over the sole medially and laterally. A hypermobile first metatarsal is mechanically incompetent. Instead of providing a firm and stable point for weight-bearing and locomotion, its head becomes displaced dorsally. Some patients overcome this handicap by relying for stability on the second metatarsal;

FIG. 19

Hallux rigidus gait is shown in Figure 19; normal gait is shown for comparison in Figure 20.

FIG. 20

others develop the *hallux rigidus gait*. From a study of the callosities on the patient's feet, from the peculiarities of wear seen in old shoes and from statements made by observant patients, this abnormal gait can be analysed. The weight of the body rolls along the outer side of the foot until the heel is well off the ground and the heads of the fourth and fifth metatarsals are bearing weight; it then passes medially across the callosity covering the middle three metatarsal heads to the second phalanx of the great toe, by-passing the metatarso-phalangeal joint (Figs. 19 and 20). The push-off is effected mainly by the four outer toes and to some extent by the pad of the great toe. The proximal joint of the hallux plays no part: its function is taken over by the hypermobile interphalangeal joint. In this gait the metatarso-phalangeal joint is protected from direct weight-bearing pressure. The joint is held in flexion by the flexor brevis hallucis and is not in contact with the sole. At the same time the first metatarsal is stabilised: for contraction of the flexor brevis prevents the dorsal displacement of the bone and converts it and the first phalanx into a single, stable, downpointing unit. As a result, the forces acting in the long axis of the first metatarsal are transmitted direct to the shallow articular cup on the base of the first phalanx (Figs. 21 and 22). The head of the first metatarsal causes attrition of the centre of the basal articular cartilage in exactly the same way as a pestle removes the glaze from the deepest portion of a well-used mortar. The dorsal erosion appears later. It is due to dorsiflexion of the joint against the resistance of the shortened flexor brevis tendon, which holds the two articular surfaces closely applied together. In early cases full dorsiflexion of the joint can be obtained under anaesthesia. It is probable, therefore, that the shortening of the flexor brevis at this stage is due to spasm. In the chronic case contracture of the muscle prevents full dorsiflexion even under anaesthesia.

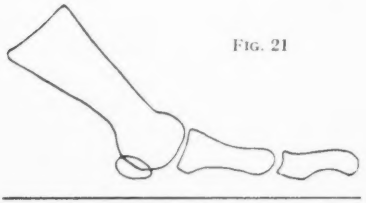


FIG. 21

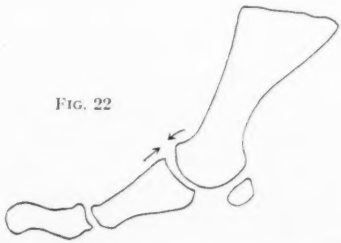


FIG. 22

The outlines above were traced from radiographs of the two feet of a patient with left hallux rigidus. The feet were examined in the push-off phase. Figure 21—In the normal right foot the two phalanges of the great toe are horizontal; the body-weight is transmitted into the base of the phalanx, the flexor brevis tendon and the sesamoids. Figure 22—The first phalanx of the left foot is dorsiflexed and the sesamoids are well above the horizontal line; the arrows indicate the compressive effects of passive dorsiflexion.

Once the cycle of osteoarthritis has been begun by a cartilaginous erosion, fibrillation and disappearance of the cartilage and formation of osteophytes follow. But even in advanced cases the situation of the early lesions is recognisable. Cartilage loss and eburnation of underlying bone are most marked in the centre of the base of the phalanx; osteophytic lipping is most pronounced at the dorsal margin of the joint. Later, abnormal strains and stresses cause osteoarthritis in the interphalangeal joint as well.

Two observations suggest that the abnormal gait precedes the appearance of symptoms. 1) Patients who had had pain only for a few weeks showed such well-marked changes in their feet and shoes that the duration of the abnormal gait was clearly a matter of months rather than weeks. 2) It was observed in cases of unilateral hallux rigidus that the painless great toe of the other side often lacked dorsiflexion, that the foot showed the characteristic callosities, that there was smooth skin under the proximal joint of the great toe, and that subsequently this toe became painful.

It is reasonable to expect that the strains and minor injuries of normal day-to-day activity would affect mainly the right foot in right-footed persons and the left foot in left-footed persons. In our adolescent group eleven of the fifteen unilateral cases of hallux rigidus were ipsilaterally footed. In bilateral cases, the more painful side is almost invariably determined by the patient's footedness.

SUMMARY

1. Clinically, hallux rigidus is a painful condition of the joints of the great toe associated with loss of dorsiflexion of the first phalanx.

2. Pathologically, the morbid changes are those of a traumatic synovitis followed by an early development of osteoarthritis, the initial lesions of which are erosions of the cartilage at the centre and near the dorsal margin of the base of the proximal phalanx. There is no fundamental pathological difference between the adult and adolescent varieties of hallux rigidus. Both represent stages in the developmental cycle of osteoarthritis in the proximal joint of the great toe.

3. The radiographic density and apparent fragmentation of the phalangeal epiphysis do not represent an abnormality of the bone and have no significance in the etiology of hallux rigidus.

4. The cause of hallux rigidus is an abnormal gait developed either to protect an injured or inflamed metatarso-phalangeal joint from the pressure of weight-bearing, or to stabilise a hypermobile first metatarsal. The effects of this gait are to transfer most of the pressure from the flexor brevis tendon and the two sesamoids to the base of the first phalanx. Excessive pressure on this joint predisposes to osteoarthritis.

5. Evidence of this abnormal gait is found in the peculiarities of wear seen in old shoes.

6. There is a high correlation between unilateral hallux rigidus and the patient's footedness.

Our thanks are due to the orthopaedic surgeons of the General Infirmary at Leeds for permission to treat and report on their cases, and to Mr C. R. Chapman, F.B.I.S.T., for the drawings of the shoes.

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INTERNAL ROTATION DISLOCATION OF THE SHOULDER

Report of a Case

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Dislocations of the shoulder other than anterior dislocations are uncommon: complete posterior dislocations, for instance, account for probably no more than 1 per cent. of all cases, but—being readily shown by routine radiography—are unlikely to be overlooked. Less obvious displacement of the humeral head does occur, however, and diagnosis is liable to be missed. Such cases have sometimes been classified as posterior subluxations. They may present serious difficulties because the opportunity for straightforward manipulative reduction is lost and the hazards of late manipulation and open reduction (Watson-Jones 1943) have to be faced. The following case report illustrates not only the diagnostic and therapeutic difficulties associated with this type of injury, but also the need for defining more clearly the exact nature of the displacement. Open reduction provided an opportunity of determining accurately the nature of the pathology.

CASE REPORT

A woman aged fifty-nine, healthy and unusually muscular, fell from her autocycle on to the outstretched left upper limb. There was immediate severe pain in the left shoulder and no movement of the arm was possible. Antero-posterior and lateral radiographs taken within a few hours of the injury were reported as showing nothing abnormal. Her doctor was not satisfied and sent her to another hospital. Further radiographs, including stereoscopic films, failed to show any abnormality. A diagnosis of severe " sprain " was made. Four weeks later pain and limitation of movement were still present and the patient was referred to the author.

On examination, the left humerus was found to be held in maximal adduction and internal rotation. The head could not be palpated either in its normal place or anteriorly. Nor was it present in one of the two typical positions of posterior dislocation. The powerful deltoid muscle and remnants of the post-traumatic swelling made palpation uncertain. No movement of the shoulder was possible; fixed adduction was so extreme that pressure of the elbow had left a red mark on the skin of the patient's flank. There were no signs of vessel or nerve involvement. Examination under an anaesthetic confirmed that the shoulder was still firmly locked. Some scapular movement was possible, but no true shoulder movement. A gentle attempt at manipulation was made. While traction was applied the inward rotation was further increased. The joint unlocked with an audible snap and about half the normal range of external rotation and abduction became possible. It was foreseen that redisplacement might occur and in spite of precautionary measures this in fact happened within forty-eight hours. Locking was once more complete. Open reduction was planned.

Operation was undertaken five weeks after the accident. The shoulder was exposed through Bankart's anterior approach. The subscapularis tendon was found to be stippled with old haemorrhages and adherent to the capsule. The capsule, the front of which was thickened and rather slack, was incised. It was then seen that the greater tuberosity of the humerus was directed forwards, and that the neck of the humerus faced the glenoid. The articular surface of the head of the humerus could not be seen; the head, rotated inwards through nearly 90 degrees, was clearly locked at the posterior rim of the glenoid. Reduction was

achieved by strong traction and lateral rotation. Multiple adhesions to the posterior part of the capsule were divided. The wound was closed in layers. The arm was immobilised in abduction and outward rotation for a few days, after which exercises were encouraged. The post-operative course was complicated by a small pulmonary infarct, possibly derived from the axillary vein, but a useful range of painless shoulder movement was regained within four weeks of operation. One year later the patient wrote to say that movement had increased further, and that the shoulder was painless. Power was good; she was able to do her hair, and was undertaking heavy housework and farm work.

DISCUSSION

In this case the doctor, rightly suspecting dislocation on clinical grounds, was misled by the inability of radiological methods to establish the diagnosis. The shortcomings of the routine methods of radiography of the shoulder have been discussed by Warrick (1948), who recommended that a vertical view should be taken with either the tube or a curved cassette placed in the axilla. His illustrations of three cases show clearly a posterior displacement of the head of the humerus. In his opinion (personal communication) two of his cases were identical with that described here. But in Warrick's cases it was possible to obtain sufficient abduction of the arm to place either the tube or the film beneath the axilla: it is therefore a matter of doubt whether they were really identical. In the present case no abduction was possible and it was impracticable to obtain the views recommended by Warrick. One of the radiographs of the writer's patient shows the state of extreme inward rotation (Fig. 1), but before operation it was incorrectly interpreted.

The difference between internal rotation dislocation and the usual type of posterior

FIG. 1

Internal rotation dislocation of the shoulder. Radiograph before operation showed extreme internal rotation of the humerus, but the significance of this was not at first appreciated.

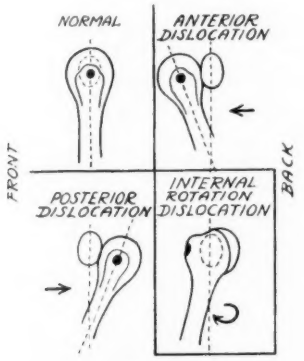

FIG. 2

Lateral aspect diagrams of left shoulder, showing the difference between common types of anterior and posterior dislocations and internal rotation dislocation. In the latter the front of the neck of the humerus is in contact with the glenoid fossa.

dislocation is illustrated in Figure 2, which shows the shoulder as seen from the lateral aspect; the most lateral point of the greater tuberosity is indicated by a black spot. This is directed laterally in the normal position and in the usual types of anterior and posterior dislocation. In internal rotation dislocation it is directed anteriorly. It will be noted further that in anterior and posterior dislocations the glenoid is not covered by the upper end of the humerus, which is displaced respectively forwards and backwards. But in internal rotation dislocation the upper end of the humerus maintains a relationship to the glenoid, not by its articular surface as in the normal shoulder, but by the anterior aspect of the neck. Early diagnosis alone can ensure early reduction by manipulation, which in the first few days should present little difficulty. Since radiography cannot always be relied upon to provide clear evidence of displacement, diagnosis should be based on the clinical findings of locking of the limb in adduction and inward rotation.

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OSTEOLYTIC BONE SYPHILIS

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Bone lesions typical of syphilis include the periosteal node, diffuse osteoperiostitis, and the gumma. Standard descriptions of these syphilitic lesions emphasize that new bone formation usually exceeds bone destruction; but in the cases here reported osteoporosis was the striking feature, and it was much greater than the new bone formation.

CASE REPORTS

Case 1. Indian woman, aged 25 years—Four years before admission noticed swelling over the inner end of the right clavicle extending gradually over the shoulder and upper arm, associated with aching pain made worse by movement. She had one living child; there had been two miscarriages, one at two months and one at three months. *On examination* there was generalised swelling and tenderness over the right upper chest and shoulder. The clavicle was not palpable because of the swelling. Movements of the shoulder were full but painful. The Wassermann and Kahn tests were strongly positive. Radiographs showed gross destruction of the clavicle; faint mottling in the middle third of the bone was all that remained (Fig. 1). Radiographic changes were seen also in the first rib and in the humerus; the anterior half of the first rib was destroyed; in the humerus there was destruction of two-thirds of the thickness of the shaft, and this lesion, by itself, resembled a bone tumour. *Treatment*—The patient was given three and a half million units of penicillin by three-hourly injections over a period of eight days. The pain was relieved, the shoulder felt stronger, and the patient left hospital. Ten months later there were no symptoms. The Kahn test was then negative and radiographs showed that the lesions had healed (Fig. 2).

Case 2. Malay man, aged 25 years—Complained of pain and swelling of the left shoulder of three months' duration. *On examination* there was a tender swelling over the inner half of the clavicle. There were two large flat paper-like scars on the forearm, said to be the result of large ulcers which had developed several years earlier and had healed spontaneously. The patient gave no history of chancre or rash. He was familiar with yaws but said that he had never suffered from it. The blood Wassermann and Kahn tests were strongly positive. Radiographs showed erosion of the inner quarter of the left clavicle and destruction of the outer end. Neoarsphenamine was given intravenously and potassium iodide by mouth. The pain was relieved within seven days.

Case 3. Chinese male, aged 21 years—Complained of multiple discharging ulcers over the left shoulder. One year before admission noticed redness and tenderness over the upper part of the left shoulder, and then an ulcer which discharged pus; the ulcer and sinus healed but new openings appeared. As one ulcer healed a new one formed behind it, leaving a thin white scar. *On examination* the inner ends of both clavicles were enlarged and tender (Fig. 3). There was a flat scar with an ulcerating advancing edge (Fig. 4) and the history, clinical appearances and positive Wassermann and Kahn tests left no doubt that this was a gummatous ulceration of the skin. Radiographs showed areas of bone destruction in both clavicles (Fig. 5). As a therapeutic test the patient was put on potassium iodide, thirty grains thrice daily by mouth, and neoarsphenamine intravenously. Healing of the ulceration began in three weeks and was complete in six weeks, thus confirming that the lesions were probably syphilitic. A course of three and a half million units of penicillin was given. The swelling and tenderness disappeared.

Case 4. Chinese woman, aged 25 years—Two months' history of painful swelling of the left foot, increasing in size. The pain was never severe. *On examination* there was a red and tender swelling over the medial side of the dorsum of the foot with oedema. Radiographs showed an osteolytic lesion of the first metatarsal with pathological fracture. The blood Kahn test was strongly positive. Plaster was applied from the metatarsal heads to the tibial tuberosity, and anti-syphilitic treatment was instituted. Two months later, radiographs showed union of the fracture and recalcification of the bone. Radiographs four months later showed final consolidation.

Case 5. Chinese man, aged 32 years—Intermittent fever and rigors for three months before admission; six weeks before had fallen while walking and fractured the left tibia and fibula; one week before admission had been trying to walk but again fell and fractured the right femur. *On examination* he looked ill and emaciated. There was gummatous ulceration of the oral pharynx and soft palate with old scars and adhesion of the left half of the soft palate to the posterior pharyngeal wall. The penis showed scarring of the glans

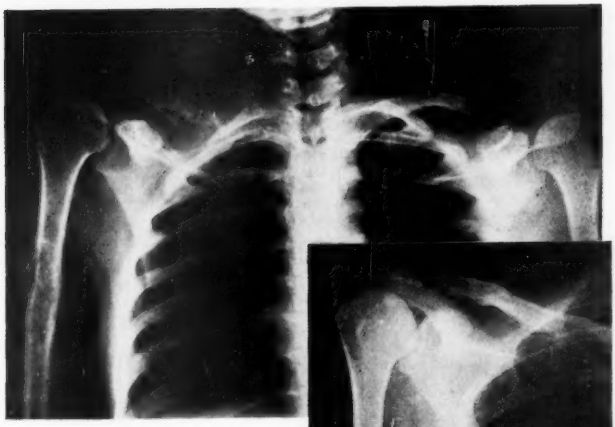

FIG. 1

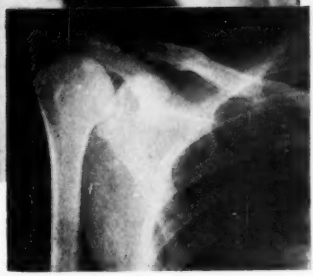

FIG. 2

Case 1. Syphilitic lesions of the right clavicle, first rib and humerus. The clavicle is represented only by faint mottling in the middle third (Fig. 1). Ten months later, after treatment, the lesions are healed (Fig. 2).

FIG. 3

FIG. 4

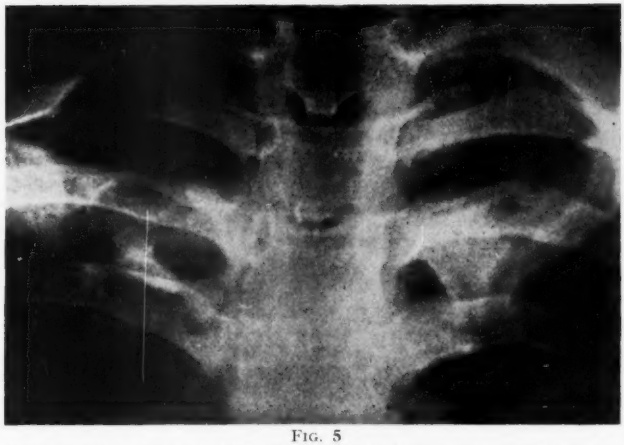

FIG. 5

Case 3. (Figs. 3, 4 and 5.) Syphilitic lesions of the inner ends of both clavicles with gummatous ulceration of the skin over the back of the left shoulder.

and constriction of the external meatus. In the lower limbs there was extreme wasting of all the muscles. The upper end of the left tibia was irregularly enlarged, hard and tender. There was an obvious fracture of the mid-shaft of the right femur. *Radiographic examination*—There were fractures of the tibia and fibula in their upper thirds; the whole tibia was diseased, the shaft being speckled with small clear lesions. There was an area of cortical erosion just above the fracture and several areas of demarcated bone destruction in the shaft. Periosteal thickening extended throughout the length of the bone. At the fracture-site there was sclerosis and callus formation and both bones showed evidence of union. In the femur there was a fracture of the middle third through the site of an extensive osteolytic lesion (Fig. 6).

FIG. 6

FIG. 7

Case 5. Pathological fracture of the femur through the site of an osteolytic syphilitic lesion; there is also a periosteal node below the lesser trochanter and other areas of bone destruction in the shaft (Fig. 6). After immobilisation in a Thomas's splint with anti-syphilitic treatment the bone lesions healed and the fracture united (Fig. 7).

There were areas of bone destruction in the shaft of the bone above the fracture with a typical periosteal node just below the lesser trochanter. The blood Kahn test was strongly positive. The limb was immobilised in a Thomas' splint and anti-syphilitic treatment was given. The general condition of the patient improved rapidly and the fracture united within four months (Fig. 7).

DISCUSSION

Standard text-books of pathology do not describe destructive syphilitic lesions in long bones and few radiologists recognise them. In the young adult with acquired syphilis the osseous involvement is usually atrophic, whereas in older patients who have had the disease

for many years the manifestation is nearly always hypertrophic (Stewart 1938). All the patients in this paper were young, their ages ranging from twenty to thirty years, and the lesions could be described as atrophic. Such atrophic syphilitic lesions of bone may cause pathological fracture as in Case 5 of this series and in the case reported by Jackson Burrows (1937).

Osteolytic syphilis of the tibia was described by Ungerman, Vicary and Eldridge (1938); radiographs showed multiple destructive lesions in the cortex of the tibia without periosteal or medullary changes, and the lesions disappeared after anti-syphilitic treatment. The present writer has seen a similar case with destructive syphilitic lesions of the tibia, talus and calcaneus, closely resembling secondary carcinomatous deposits. The diagnosis may be difficult when the lesions are osteolytic. The radiographic appearances in the humerus in Case 1 of this series resembled those of a bone sarcoma; and the localised punched-out lesions may be confused with the secondary deposits of malignant disease. Biopsy is often inconclusive and blood tests are not always positive, so that amputation may even be considered in the mistaken belief that the lesion is a bone tumour. In doubtful cases it is wise to use penicillin as a therapeutic test. If the lesion is syphilitic, symptomatic relief will occur within seven to fourteen days.

I thank Dr Vickers, Director of Medical Services, Singapore, for his permission to publish this article.

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OSTEOCHONDRITIS OF THE CUBOID ASSOCIATED WITH TUBERCULOSIS OF ADJACENT TARSAL BONES

Report of a Case

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A Chinese boy, aged six years, was seen at the Chung Shan Memorial Hospital, Shanghai, on August 12, 1947, for discharging sinuses over the left neck, left elbow and dorsum of the left foot. The sinuses, which had been present for more than a year, began as multiple nodules in the neck, and ruptured. The clinical diagnosis was tuberculosis of the cervical glands, left elbow and left foot. Radiographs of the left foot showed moderate osteoporosis of the bones, but the cuboid presented disc-like flattening with moderate sclerosis and a sharp outline (Figs. 1 and 2). There was moderate soft tissue swelling with cloudiness of the tarsal region, especially dorsally. The radiographic appearances suggested osteochondritis of the cuboid, despite the clinical diagnosis of tuberculosis.

The patient was seen again nine months later, when he complained of a running nose, cough and fever for three days. The general condition was satisfactory. On clinical examination of the lungs there were wheezy breath sounds in all areas and a few inconstant *râles* over the right upper chest in front. Pulmonary tuberculosis was suspected. The multiple sinuses on the left side of the neck were neither better nor worse, but the condition of the left elbow and ankle seemed improved. A radiograph of the chest showed heavy markings and haziness at the hila, with patchy clouding in both middle and infraclavicular zones and a few calcified opacities in the hilar and lower zones, indicative of pulmonary tuberculosis. There were several calcified nodules of medium size throughout the central abdomen. Radiographs of the left foot showed that the cuboid had become larger and thicker, although still somewhat flat, rather sclerotic and sharply outlined (Fig. 3). A tiny piece of bone was seen at its lateral aspect. There were patchy areas of destruction within the third cuneiform bone, suggesting tuberculosis. The other tarsal bones remained osteoporotic, and there was still moderate soft tissue swelling. The right foot showed a normal cuboid (Fig. 4). Radiographs of the left elbow showed moderate erosion of the articular surfaces of the radius and ulna.

The left foot was treated by immobilisation in plaster. Six months later, radiographs showed further increase in the size and thickness of the cuboid, which was less dense than before and fairly sharp (Figs. 5 and 6). The tiny bony fragment at the lateral aspect of the cuboid was still present. There was further destruction of the third cuneiform bone, but its outline remained sharp (in appearance not unlike caries sicca of the shoulder). The cuneiforms, cuboid and navicular were more crowded together. Soft tissue swelling and clouding were still evident, but less marked. The left elbow showed further slight destruction.

When last seen on December 28, 1948, the patient's general condition was good but the cough was not improved. The lesions in the cervical region were healed and the sinuses in the left foot were covered with dry crusts.

Comment—There can be little doubt, on the radiographic evidence, that this was a case of osteochondritis of the cuboid. Similarly, from the clinical and radiographic findings and despite lack of bacteriological proof, one can safely regard the other lesions of the left foot, left elbow, neck and chest as tuberculous in nature. Evidence of widespread tuberculosis was further strengthened by the demonstration of calcified mesenteric nodes. It was unfortunate that the patient could not be observed over a longer period.

FIG. 1

FIG. 2

Figures 1 and 2—The left foot shows disc-like flattening and increased density of the cuboid suggesting osteochondritis.

Figures 3 and 4—Nine months later the cuboid is relatively thicker but still shows increased density. There is patchy destruction of the third cuneiform, suggesting tuberculosis (Fig. 3). The normal right foot is shown for comparison (Fig. 4).

FIG. 3

FIG. 4

FIG. 5

FIG. 6

Condition of the tarsus after a further six months. Note better shape of cuboid, which is of more normal density. Slightly increased destruction of the third cuneiform.

DISCUSSION

Osteochondritis of the cuboid is uncommon. King (1935), in his exhaustive monograph on osteochondritis, cited only one recorded example, namely, the case reported by Lance in 1926. Brailsford (1944) mentioned a further case described by Silferskiöld in 1926. The cause of osteochondritis in general is still uncertain, but trauma, infection or developmental anomaly are often held to be causes. Our discussion here will naturally centre on the question of tuberculosis in relation to osteochondritis.

King (1935) states that most authors consider that tuberculosis is not related to osteochondritis, but some others accept a relationship. Köhler (1935), in his section on osteochondritis of the tarsal navicular, remarks that the condition has no relation to tuberculosis. Nevertheless, Greenwood (1927) among others held that the radiographic appearance of tuberculosis may simulate that of osteochondritis of the navicular. Dale (1942) also reported a case that showed changes in the right tarsal navicular suggestive of osteochondritis (the opposite navicular presenting a similar appearance). Subsequently the condition of the right foot deteriorated and material from the right tarsus yielded a growth of tubercle bacilli. Dale offered three possible explanations: first, that the case was one of tuberculosis originating in the navicular, in which case it would have to be accepted that tuberculosis may simulate osteochondritis; or, second, that there was primarily osteochondritis of the navicular on which tuberculosis had been superimposed (a diagnosis of osteochondritis seeming to be supported by the appearance of the left navicular); or, third, that osteochondritis and tuberculosis of the navicular are one and the same thing, the title osteochondritis being applicable only when the disease is mild and local to the navicular. Subsequently Dale made a search through his collection and found another case which showed radiographic appearances of osteochondritis but which developed pulmonary tuberculosis two years later. He concluded that osteochondritis of the tarsal navicular and tuberculosis are at least clinically associated. He observed that, without radiographic examination, cases of osteochondritis would be—and were—diagnosed as mild tuberculous lesions, and that the characteristic radiographic appearances may simply represent the response of developing bone, at certain sites, to a mild infection, either tuberculous or non-specific.

So far no report has been made on the relationship between osteochondritis of the cuboid and tuberculosis, but it is clear that the problems discussed above are relevant. The case reported here, besides being unusual, seems remarkable for the fact that despite the presence of a slowly progressive tuberculous lesion of the third cuneiform bone, and possibly of contiguous structures, the osteochondritis of the cuboid went on to progressive recovery. It seems probable that in this case the tarsal osteochondritis and tuberculosis were two separate entities pursuing different courses in spite of their proximity to each other.

SUMMARY

1. A case of osteochondritis of the cuboid, with co-existing tuberculosis of the third cuneiform bone, is reported.
2. The possible relationship between osteochondritis and tuberculosis is discussed.

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AN UNUSUAL COMPOUND FRACTURE

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A milk roundsman on a delivery tricycle was involved in a collision with a similar vehicle. His left hand, resting on the handle-bar, was driven forcibly against the bell which was fixed to the bar. The lever of the bell was driven into the lateral border of the second metacarpal and became firmly wedged there. Attempts to disengage it from his hand were unsuccessful; the metal band holding the bell in place was therefore divided with a hacksaw and the patient, with the bell still in his hand, was removed to hospital.

Fig. 1

Fig. 2

The lever of the bell (shown about three-quarter size in Figure 2) is wedged in the second metacarpal.

On admission his general condition was satisfactory. Radiographic examination showed that the lever of the bell had penetrated the lateral cortex of the neck of the second metacarpal (Fig. 1). When efforts to extract it manually failed, the margins of the skin wound were excised under general anaesthesia and the wound was enlarged. The bell (Fig. 2) was gripped with powerful pliers and gently eased out of the bone: it was found to have penetrated as far as the lateral margin of the articular cartilage of the metacarpal head, and the fracture to extend into the metacarpo-phalangeal joint. The bone cavity was curetted and 500,000 units of penicillin solution were instilled into the wound. The skin was sutured and an anterior plaster slab applied. The post-operative course was uneventful. Three weeks after the injury the wound was firmly healed. Flexion of the metacarpo-phalangeal joint was limited by 10 degrees but other joint movements were normal.

AN EXPERIMENTAL STUDY OF TENDON GROWTH IN THE RABBIT

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The post-natal growth of muscles and tendons is of interest both from the anatomical and from the orthopaedic point of view. But whereas much information is available on the growth and especially the differentiation of muscle, tendinous tissue has been relatively neglected. In fact, current opinion about tendon growth is largely based on the analogy of muscle.

Present knowledge of the development of muscle and tendon has resulted mainly from histological examination of material from young animals. Many authors have described the appearance of the end of a growing muscle belly where it joins the tendon, and the literature has been reviewed by Prenant, Bouin and Maillard (1911) and by Häggquist (1931). In the undifferentiated end of a muscle fibre there is a high concentration of nuclei and this is regarded as the region of most rapid muscle growth. Felix (1889) nevertheless believed that in the foetus some growth occurs throughout the length of the muscle fibre. The high concentration of nuclei extends into the tendon near its junction with the muscle, and it has been assumed that this indicates a multiplication of fibroblast nuclei which must be accompanied by a rapid deposition of collagen fibres. It seems unlikely, however, that the end of the tendon is the only site of fibroblast proliferation; and it would be reasonable to expect that new collagenous tissue might be laid down throughout the whole length of the tendon, and a means of interstitial longitudinal growth thus provided. Nevertheless this is not a generally accepted opinion (Haines 1932). Mason and Shearon (1932), investigating the capacity of tendinous tissue to form new collagenous fibres, divided the tendons of adult rabbits and found that although the greater part of the repair was accomplished by fibroblasts invading the lesion from without, some new collagen was laid down and organised into normal tendinous tissue by intrinsic fibroblasts. They thus showed that even in the adult new tendon fibres can originate from cells lying along the length of the tendon.

In dealing with a relatively slow dynamic process such as tendon growth, the examination of histological sections may be misleading. Additional sources of information should be sought, and a second possible approach to the problem is to examine living muscles and tendons *in situ* in the growing animal. Speidel (1938) observed the myomeres in the tails of living tadpoles over a long period and confirmed the hypothesis that the main site of muscle growth was at the end of the muscle fibre. He was not primarily concerned with tendon growth, but he recorded his impression that the growth of the tendinous part of the myomere also occurred mainly at its junction with the muscle.

A third method of investigation, which forms the basis of this paper, is to mark tendons along their length in young animals and to observe whether the marks become separated during growth This is an adaptation of Hunter's fundamental experiments on bone growth. A similar method was used by Warwick and Wiles (1934) to study the growth of periosteum. They made marks with indian ink along the periosteum of young rabbits and measured the distance between the marks at the time of the operation and again after an appropriate period of growth. They were able to demonstrate that growth of periosteum occurs along the whole length of the bone and not merely at the region of the epiphysial cartilage. In this investigation the same method has been applied to the study of tendon growth. Small marks were made with indian ink along the length of various tendons in young rabbits. The distance between them was measured at the time of operation and after death two to five months later; and the amount of growth and its situation was determined.

EXPERIMENTAL MATERIAL AND METHODS

Rabbits about one month old were used. These are readily obtainable, their tendons are of a convenient size, and although growing rapidly they stand the operation well. The tendons most convenient for study, on account of accessibility and adequate length, were those of tibialis anterior, extensor hallucis longus and the peroneal muscles. Muscles (*e.g.*, gastrocnemius) whose fibres have a complicated junction pattern with the tendon were avoided, because interpreting growth processes near the muscle-tendon junction would have been more difficult. Since the intention in this first series of experiments was to secure qualitative rather than quantitative data, no special precautions were taken to ensure that all the animals used were of precisely the same breed, age and size. Only a small series of rabbits was used for each particular tendon studied. It was hoped that a fairly general picture of the method of tendon growth would result from using a variety of different tendons.

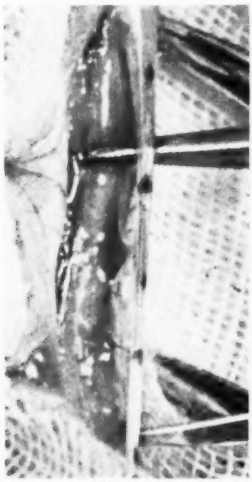

FIG. 1

FIG. 2

Figure 1, a photograph taken during operation on a five-week-old rabbit, shows indian ink marks along the tendon of extensor hallucis longus. (Approximately $\times 3{\cdot}5$.) Figure 2 shows the tendon eleven weeks later; the same indian ink marks can be seen. (Approximately $\times 2$.)

Operative technique—Under general anaesthesia the tendon was exposed through a skin incision and the tendon sheath incised. Small marks were made with indian ink at intervals along the length of the tendon by means of a fine needle inserted so that some of the ink was deposited within the tendon substance. Before the tendon was marked its surface was dried with a swab to prevent spreading of the ink in the surface film of fluid. The ink marks were usually about one millimetre in diameter. The distance between the marks was measured with fine dividers on a metal ruler graduated to half a millimetre (Figs. 1 and 2). In some animals a pin was inserted into the bone as a fixed marker. Any movement of the tendon relative to the bone during growth was thus determined. Only the skin incision was sutured: natural repair of the tendon sheath occurred rapidly without suture. The rabbits were killed after eight to twenty-two weeks, the tendons examined and the distances between the ink marks measured to determine the growth that had occurred in the segments of tendon between the marks. The ink marks rarely faded; they tended to spread, but only very slightly, and measurements could be taken from the centres. Some control experiments are described overleaf.

Control experiments. *Gross morphology of the experimental tendon*—The length of the tendon under investigation was compared after death with its normal counterpart from the opposite limb. In no case was the difference more than two millimetres, though the tendon which had been operated on was sometimes slightly thinner than its fellow. In all cases the arrangement of muscle fibres at the musculo-tendinous junction appeared unaltered; the girth and length of the muscle belly appeared normal. The tendon sheath was found to have regained its normal macroscopic appearance; there were no adhesions limiting the movement of the muscle or tendon. A few cases of wound infection were excluded from the investigation.

Microscopic structure of the tendons—The tendon under investigation and the opposite normal tendon were examined histologically after death. Further, six young animals were killed at intervals of from seven to forty-three days after operation to determine whether there was evidence of abnormal changes in the structure of the tendon in the early post-operative period. Histological examination in these animals showed evidence of an increase in the number of fibroblast nuclei towards the surface of the tendon (Fig. 3) about ten days after operation, but no abnormality of the deeper fibres of the tendon was apparent. Control experiments on rabbits killed two weeks after operation indicated that there had been no appreciable tendon growth in that time. Since the post-operative cellular reaction at the surface of the tendon had usually subsided by the end of the second week, its possible effect on tendon growth can be discounted. Examination of specimens killed ten weeks after operation showed no important differences between the tendon under investigation and the control tendon (Figs. 4 and 5). Histological examination of the marked areas showed remarkably little tissue reaction around the ink (Figs. 6 and 7) even when the tendon was examined at a short interval after the marks were made.

Operations on adult rabbits—In order to eliminate the possibility that the operation on the tendons might lead to stretching, experiments were undertaken on the tendon of tibialis anterior in four adult rabbits. Marks were placed on the tendon and the intervals measured. The rabbits were killed after eight weeks and the measurements repeated (Fig. 8). It is clear that the distance between the ink marks has not altered significantly in the eight weeks elapsing between operation and death, and there is thus no evidence that post-operative stretching of the tendons occurs. In this experiment the difference between the first and second measurements was never greater than half a millimetre. This suggests that the method can be relied upon as sufficiently accurate for our purpose.

To summarise—These control experiments suggested that that the operation caused no significant pathological change in a tendon, and there was no positive evidence that the normal growth of the tendon was disturbed. Technique was shown to be adequately accurate.

RESULTS

The results will be classified according to the tendon studied.

Tibialis anterior—Six rabbits were used. All were about five weeks old at operation. The interval between operation and death varied from eight to fifteen weeks. The tendon was marked at intervals from the muscle-tendon junction to within about ten millimetres of the insertion. The number of marks varied from four to five, and the distance between them from two and a half to nine and a half millimetres. The results are shown in Figure 9. In every case the first mark was made on the muscle tendon-junction and this is represented in the figure by the points joined by the horizontal line.

The amount of tendon growth varied considerably in the different rabbits, but in all cases the distances between the marks increased. Interstitial growth had therefore taken place along the whole length of the tendon marked. It is evident, however, that the rate of growth was not uniform in the different segments. Growth was most rapid near the

FIG. 3

The surface of a tendon of extensor hallucis longus, which had been exposed for marking at an operation ten days before the rabbit was killed. There is an increase in the number of fibroblast nuclei on the surface. (×130.)

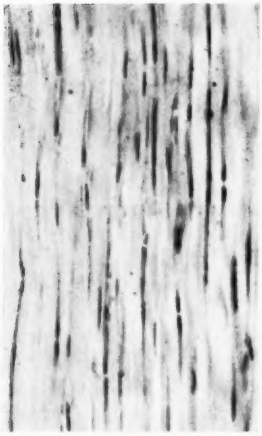

FIG. 4

FIG. 5

Figure 4—Tendon of extensor hallucis longus, marked with indian ink at an operation ten weeks before the rabbit was killed, when it was aged seven weeks. The normal appearance of the tissue is evident. (×220.) Figure 5—Tendon of the normal extensor hallucis longus from the opposite leg of the same rabbit. (×220.)

FIG. 6

FIG. 7

Figure 6—Indian ink on the surface of a tendon of extensor hallucis longus, marked eleven weeks before the rabbit was killed. (×130.) Figure 7—Indian ink in the substance of a tendon of extensor hallucis longus, marked two weeks before the rabbit was killed. The lack of much tissue reaction is evident in either case. (×80.)

muscle-tendon junction and fell off more distally along the tendon. This can be seen more clearly in Figure 10. Here the increase in length of each segment (expressed as a percentage of its initial length) is plotted against the distance of the mid-point of the segment from the muscle-tendon junction. The decrease of the growth rate as the measurements are made farther from the muscle-tendon junction is evident; it can be seen also that the most rapid decrease appears to be in the proximal part of the tendon. In the case of rabbit 1, the segment centred twenty-three millimetres from the muscle-tendon junction shows increased rate of growth. This segment was near the insertion of the tendon and it is possible that the growth rate increases again in this region. Nevertheless the length of the segments was small and an error of half a millimetre could have given rise to a difference of about 10 per cent. in the percentage increase of length. This reading therefore is not regarded as significant.

Extensor hallucis longus (proximal half)—Five rabbits were used. Their ages at the time of operation varied from three and a half to six weeks. The interval between operation and death varied from ten to sixteen weeks. Only the proximal half of the tendon was marked. The first mark was made about three millimetres distal to the muscle-tendon junction. Two to four marks were made, and the distance between them at the time of operation varied from four and a half millimetres to eight and a half millimetres. There was interstitial increase in length in all the segments, but the greatest increase occurred near the muscle-tendon junction (Fig. 11). The percentage increase in length in each segment is shown in Figure 12. The curves in general suggest a more uniform decrease in the rate of growth towards the distal part of the tendon than in the case of the tibialis anterior. However, the segments marked on the tendon of extensor hallucis longus were shorter than those on tibialis anterior, and consequently slight inaccuracies of measurement would be more misleading. The shape of the curves in Figure 12 can therefore be regarded as significant only in showing that the greatest increase in length occurs near the muscle-tendon junction.

Extensor hallucis longus (control experiment)—It was considered possible that the markings of a tendon at close intervals might cause a decrease of growth in the affected segment. The fact that the tendon operated on shows a normal total length compared with its counterpart of the opposite limb makes the possibility unlikely. But it does not exclude it entirely since the effect might be compensated by an increase in growth in the unaffected part of the tendon. To test this possibility three further experiments were performed. The tendon of extensor hallucis longus was exposed. Only two or three marks were made, one a few millimetres from the muscle-tendon junction, and the others on the tendon over the distal part of the tibia. The tendon sheath was incised only at these points. Thus a long segment of the tendon was defined and the length of tendon between the marks was undisturbed. The rabbits were five weeks old at the time of operation; they were killed after ten to eleven weeks. The conditions were thus comparable to those of the previous experiments. Figure 13 shows the increase of length in the segment marked. Comparison with Figure 11 indicates that the total growth in several segments of the tendons with multiple marks is closely similar to that which occurred in the single long segment in these experiments. Therefore it appears that the placing of multiple marks along the length of a tendon does not interfere with its growth significantly.

Peroneal tendons—Two rabbits were used. One was four weeks and the other eight weeks old at the time of operation. The tendons of peroneus brevis, tertius and quartus were exposed on the dorsum of the foot. All three tendons were marked. Two marks were placed on peroneus brevis to define a segment of tendon the distal end of which was its insertion. The distal marks on peroneus tertius and quartus were placed about eight millimetres from the insertion of the tendons. The rabbits were killed after nineteen to twenty-two weeks. The results are shown in Figure 14. Increase in length occurred in all the segments. Since a fairly short length of tendon was used in only two rabbits it is hardly justifiable to draw quantitative conclusions with regard to the growth rate. But the figures indicate that interstitial growth in the length of a tendon occurs as far distally as its insertion.

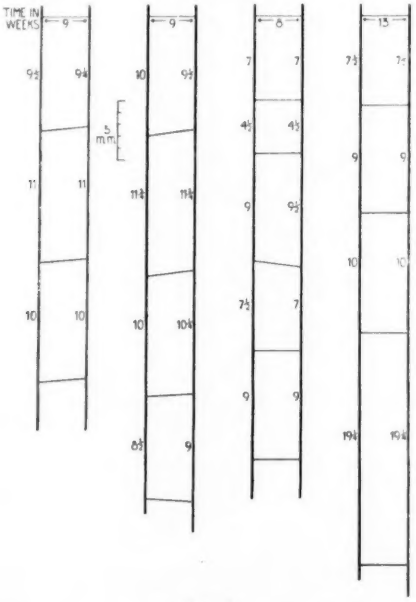

FIG. 8

Diagram illustrating the lack of stretching of the marked tendons of tibialis anterior of four adult rabbits, which were killed about ten weeks after the operation. The vertical lines are in pairs, the first member of each pair representing the tendon at the time of operation and the second at death. Each of the four pairs represents one of the experimental rabbits. Horizontal or oblique lines join the positions of each ink mark on the tendon at the time of operation and at death. (In Figs. 9, 11 and 13, similar conventions are used.) All the diagrams are drawn to scale and hence show the amount which each segment of the tendon has grown.

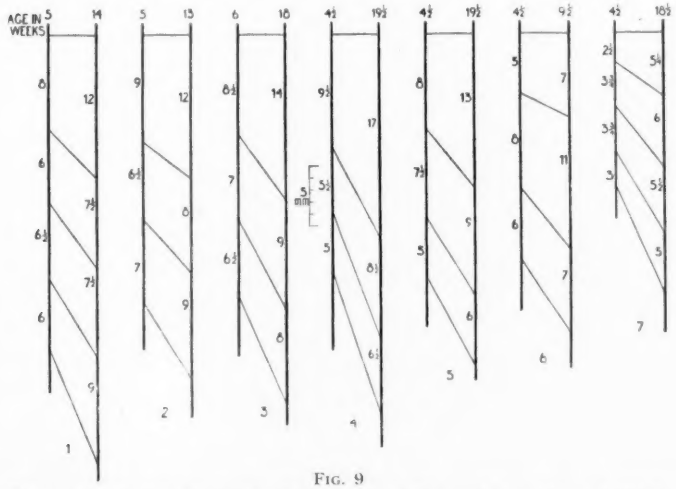

FIG. 9

Diagram illustrating the longitudinal growth of the marked tendons of tibialis anterior in seven young rabbits.

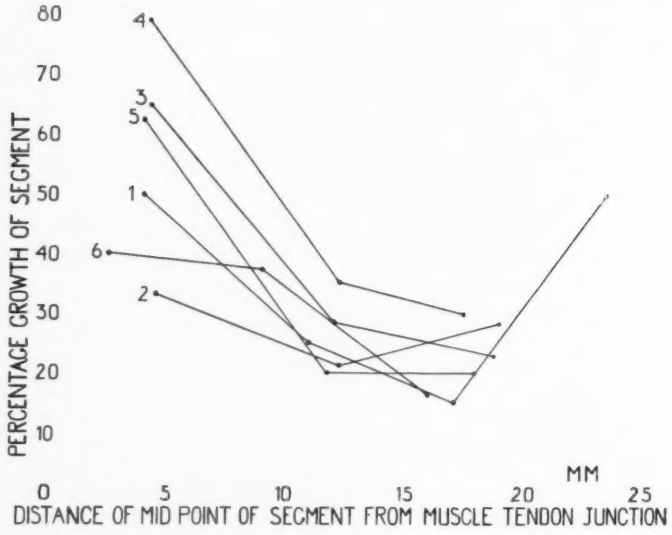

FIG. 10

Diagram illustrating the amount of growth in the various segments marked in tendons 1 to 6 of Figure 9. The number by the side of each curve refers to the tendon, which can be identified in Figure 9 by the number beneath each pair of vertical lines.

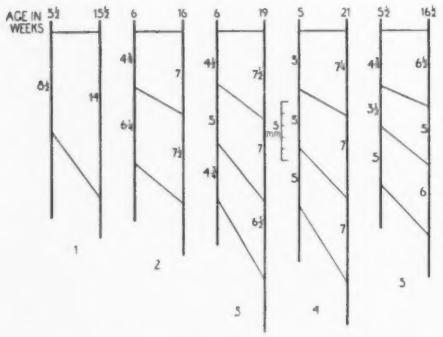

FIG. 11

Diagram illustrating the longitudinal growth of the marked tendons of extensor hallucis longus in five young rabbits.

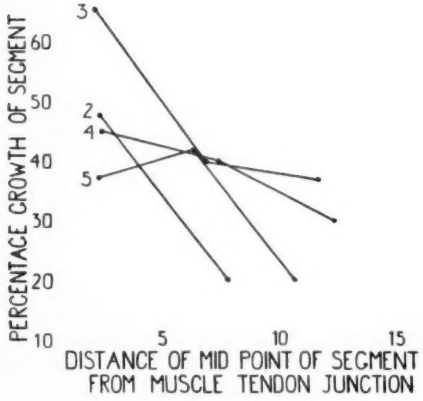

FIG. 12

Diagram illustrating the amount of growth in the various segments marked in tendons 2 to 5 of Figure 11. The number by the side of each curve refers to the tendon, which can be identified in Figure 11 by the number beneath each pair of vertical lines.

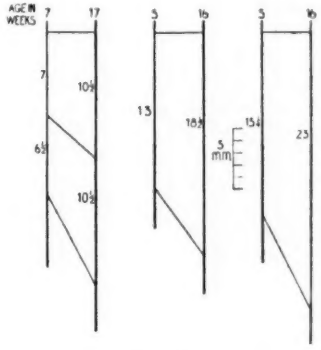

FIG. 13

Diagram illustrating the longitudinal growth of tendons of extensor hallucis longus in three young rabbits. The tendon lying between the ink marks had not been interfered with. For comparison with Figure 11.

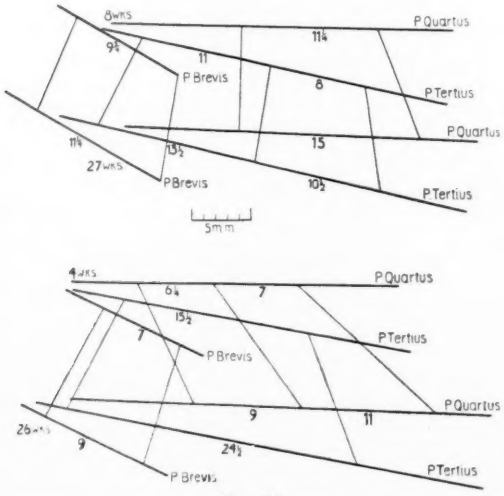

FIG. 14

Diagram illustrating the longitudinal growth of the peroneal tendons lying along the dorsum of the foot in two young rabbits.

DISCUSSION

These experiments show that interstitial longitudinal growth occurs throughout the whole length of the tendon in young rabbits. The greatest increase in length occurs near the muscle-tendon junction and there is a gradient of decreasing rate of growth away from this region. It is possible that the rate of growth increases again near the insertion of the tendon; but further experiments are necessary to determine this conclusively. There is no reason to suppose that the growth of tendons follows a different pattern in other mammals, but here also confirmatory experiments are required.

The experiments that have been undertaken do not afford any evidence how a tendon can increase in length interstitially, and it would be unwise to speculate on this point until more detailed knowledge is available concerning the histological structure of tendons and the ultimate structure of collagen. A number of problems remain unsolved. For example, there is doubt whether a muscle fibre is directly continuous with the collagen fibre at the muscle-tendon junction; whether the collagen fibre of the tendon always continues into the bone at its insertion; and whether a single collagen fibre runs throughout the whole length of the tendon. All these points are relevant to the problem of tendon growth. It has yet to be determined whether, as might be expected, a tendon lengthens by accretion of collagenous tissue at the free ends of the tendon fibre (if these occur), or at the junction with the muscle, or at the insertion into the bone. A further possibility is that increase in length is produced by the sliding of tendon fibres over one another—a mechanism that could only operate if, as seems probable, all the fibres do not extend uninterruptedly along the whole length of the tendon.

It is known that the relative and absolute lengths of muscle and tendon in the limbs of the adult animal have a relation to the contractile excursion required of the muscle (Frohse and Fränkel 1908). Alterations in the necessary excursion, such as may be caused by skeletal deformities, result in modifications of the muscles and tendons concerned. Very little is known, however, of the immediate factors determining the muscle-tendon ratio during normal growth or of the factors that determine the modifications made necessary by skeletal deformities occurring in the adult. It is possible that information bearing on these problems might be obtained by marking tendons in both adult and young rabbits and subjecting them to certain experimental modifications. For example, the tension to which a tendon is normally subjected could be altered and the distance between the origin and insertion of the muscle changed. By seeing how the tendon reacted to these new conditions light might be thrown on the factors that determine the normal form of the muscle. Experiments on these lines are now in progress.

SUMMARY

1. Small indian ink marks were made at intervals along the length of tendons in the limbs of young rabbits, and the distance between the marks was measured during the operation. The rabbits were killed two to three months later, and the amount of longitudinal growth that had occurred was determined by re-measuring the distance between the marks.

2. The experiments showed that the whole of the tendon grows interstitially in length, but that maximal growth occurs near the muscle-tendon junction.

3. Histological examination of the tendons and control experiments involving adult tendons indicated that growth was not significantly interfered with by marking the tendons.

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THE MOVEMENTS OF BONES AND JOINTS

3. The Synovial Fluid and its Assistants*

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It has been known for centuries that the synovial fluid lubricates the synovial joints. But behind this simple truth lies a problem, the very existence of which was unsuspected until the later part of the nineteenth century: why does a slippery fluid lubricate, and what are the conditions of its effective action? The solution of that problem has thrown much light upon the nature of the many varied structures found within the articular cavities.

THE CONDITIONS OF FLUID LUBRICATION

The essence of lubrication by a fluid is that a film is established and maintained between the fixed and moving surfaces as long as movement continues. When movement ceases the surfaces come into direct contact again. Two conditions are necessary for the maintenance of the lubricant film: first, the film must be thin, yet thick enough to act as a fluid and not as a grease; and second, the fixed and moving surfaces must not be parallel. (In practice there is a third condition, that the fluid should be appreciably viscous. This is not necessary theoretically, for even air can be made to act as a lubricant; but it will be seen later that viscosity plays an important part in the action of a lubricant.)

The theory of viscous fluid lubrication, which is highly mathematical, has been tested by the practice of engineers and proved by the success of inventions based upon it. The theory was first advanced by Reynolds in 1886 to account for certain facts about the distribution of pressures within a lubricated system. It was based upon the hydrodynamical theory of Stokes, a theory of the most general kind, applicable to all kinds of liquid, however thick or thin, however fast or slow moving. The writer has been at some pains to verify this last point, for, compared with the modern engineer's whirling masses, our joints move slowly. Using only simple apparatus he has seen the internal movements of viscous fluids as they are deduced from Stokes' theory; these movements were generated by the fingers of a man—that is to say, at speeds comparable with those of articular movements. It would be tedious to describe these experiments and they belong to physics rather than to anatomy; certain principles of lubrication theory must, however, be appreciated if their bearing on the internal structure of the joints is to be understood in a fruitful way. These principles can be made clear by simple experiments, and their mathematical basis can be summarised in a simple but accurate formula.

In this paper the essentials of the theory of lubrication will first be explained, and next the working of these principles in the joints; lastly, the special conditions that call for the interposition of intra-articular discs or menisci will be discussed, and an application of the theory to the sesamoid bones will be made.

CONVERGENT VISCOUS FILMS

Place a drop of rather thick canada balsam—or other liquid of the same viscosity—on a glass slide and apply a cover glass over it. The drop should be just large enough to fill the

* The first and second papers by Professor MacConaill under the general title were: 1) *Fundamental Principles, with Particular Reference to Rotation Movement;* and 2) *Function of the Musculature.* They were printed in Vol. **30–B,** No. 2 (May 1948), and Vol. **31–B,** No. 1 (February 1949), of this Journal.

space between the glass and the underlying part of the slide; it should not be too thick, yet not of " adhesive " thinness. With this preparation the following statements may be verified by simple experiments:

1) A gentle downward force applied to the cover glass is resisted by the fluid, which bulges at its margin (Fig. 1*a*). When the force ceases, the cover glass moves upwards again.

2) A gentle upward force applied to the cover glass—by means of a thread attached to it by sealing wax—is resisted by the fluid. The fluid takes up a concave form vertically at its margin; and when the force ceases to act the cover glass moves downwards again (Fig. 1*b*).

3) Any attempt to push the cover glass in a direction parallel to the slide is resisted and brings the cover glass closer to the slide (Fig. 1*c*).

4) If one end of the cover glass be slightly raised and the glass then be pushed in the direction away from the raised end, the cover glass will glide easily over the slide (Fig. 1*d*).

5) If the same end of the cover glass be raised, but the glass be pushed in the direction of the raised end, the glass will tend further to approach the slide (Fig. 1*e*).

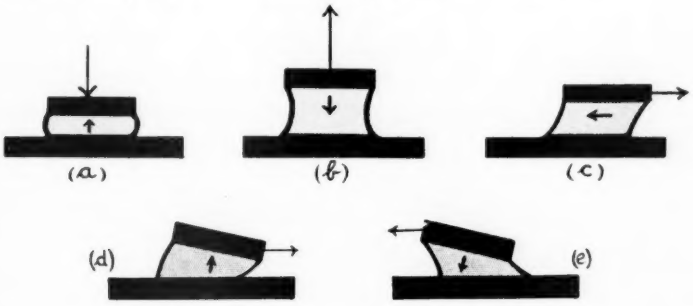

FIG. 1

Diagrams showing the forms taken by a viscous fluid between two plates, and the counter-forces developed in it in response to movement of one (the upper) surface. The upper arrow shows the direction of motion of the upper surface. The lower arrow shows the direction of the counter-force of the fluid. (*a*) direct compression; (*b*) direct tension; (*c*) parallel motion; (*d*) indirect compression (" convergent " film); (*e*) indirect tension (" divergent " film).

These experiments illustrate the laws which govern the behaviour of two surfaces separated by a viscous fluid:

1) When the moving surface moves parallel to the fixed surface, no force is generated to oppose the action of external agents (for example, gravity) in constraining the moving surface to come into contact with the fixed. A corollary to this is that flat surfaces, or surfaces of only slight curvature, are difficult to lubricate effectively.

2) When the moving surface is made to approach the fixed surface, either directly (experiment 1) or indirectly (experiment 4), an opposing force is generated within the fluid which can oppose the action of gravity or other external force tending to bring about contact between the surfaces. This opposing force is transient and slight when the moving surface is pushed directly towards the fixed; but it is of continued action and of effective magnitude against large external forces when the approach is indirect—that is, combined with a sliding motion.

3) When the moving surface is lifted from the fixed, either directly (experiment 2) or obliquely (experiment 5), a force is generated within the fluid which tends to bring the surfaces together, not to keep them separated.

In short, a viscous fluid between a fixed and a moving surface behaves as if it were elastic and like a piece of sponge rubber. This elasticity is continuous and effective only

under conditions stated above, namely, there must be a continued approach of the moving surface to the fixed while sliding motion is taking place. There is only one way of securing this continued approach of the moving surface to the fixed: the surfaces must not be parallel but inclined to each other, and the moving surface must move in the direction of inclination —in other words, towards the narrow part of the resultant wedge-like film of fluid. Such a fluid film is termed a *convergent viscous film*. One way of securing these conditions in practice is to make the fixed and moving surfaces curved, one surface of greater curvature than the other; the effect is to prevent parallel motion (Fig. 2). The surfaces are incongruous and, if they touch, they touch at one point only (Fig. 3).

The distribution of pressure in the film—The mathematical theory of viscous film lubrication is such that it is possible to draw a graph showing variations of pressure within the film—and this represents the counter-pressure maintaining the separation of the fixed and moving surfaces. The pressure curve, calculated and compared with the results of direct measurements by engineers, has demonstrated close agreement between theory and observation. We are not interested here in actual values so much as in the typical shape of the curve, which is shown in Figure 4. The essence of the calculation for obtaining the curve can be stated in terms of simple geometry, for the viscous fluid can be conceived as consisting of an infinitely large number of strings, or columns, of particles terminated by the two lubricated surfaces. When the system is at rest these strings are straight, as in Figure 5*a*; but when the film is convergent, and one surface in motion, the strings become bowed in greater or less degree as in Figure 5*b*. It has already been shown that the margins of such a film are convex outwards. Hence, as we pass from the left (inflowing) to the right (outflowing) part of a section of the film, the curvature of the strings changes: from being convex to the left they become convex to the right. There will, therefore, be one point where they are convex neither to the right not to the left—that is, uncurved. In other words, the bowing (k) of the strings changes from a positive sense on the left, through zero, to being a negative sense on the right (Fig. 5). The calculation of the pressure curve is based upon an equation which connects the curvature (k) of the molecular strings of the fluid with the slope (s) of the curve itself and the coefficient of viscosity (v) of the fluid. The equation is: $s=k\times v$ (Fig. 4*a*). This equation is a simplified form of a more complex differential equation; but the coefficient of friction of the fluid is one of the properties that can be calculated from it accurately. The friction varies with the speed of the moving surface, a fact which has been used to support the theory that synovial joints are lubricated by convergent films. (See below.)

It is essential to the working of the convergent film that it should be thin. In fact, the equation given above is obtained by taking a certain more complicated one, and omitting all those terms in which the weight of the lubricant fluid is taken into account: this is a measure of its thinness. Mention must next be made of the " load-line " (Fig. 5). This is the line along which the resultant of the counter-pressure of the fluid can be taken to act; it is the line of transmission of weight (or of other forces) across the joint. The load-line is nearer the thinnest part of the film than the thickest.

Finally, it is necessary to appreciate that the lubricant fluid is itself in motion between the fixed and the moving surfaces. It adheres to both surfaces, this adhesion being essential to its action. That part of it adhering to the moving surface travels with the speed of that surface. That part adhering to the fixed surface does not travel at all. The remaining parts —so many horizontal laminae—travel at speeds which are less the nearer they are to the fixed surface. That is to say, there is a " gradient of velocity " along each molecular column varying as we pass from the inflowing to the outflowing margins of the convergent film. It is this gradient that gives rise to the particular curvatures of the molecular strings.

THE LUBRICANT APPARATUS OF THE SYNOVIAL JOINTS

The hypothesis that convergent synovial films were the basis of the lubrication of the

FIG. 2

Continued approach of a moving surface to a fixed may be ensured by curved incongruous surfaces.

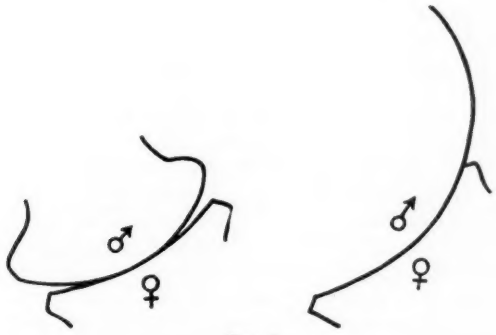

FIG. 3

When two incongruous joint surfaces are brought together they come into contact only at one point, as on the left. In the "close-packed" position of a joint the surfaces are congruous and in contact throughout the area of apposition, as on the right.

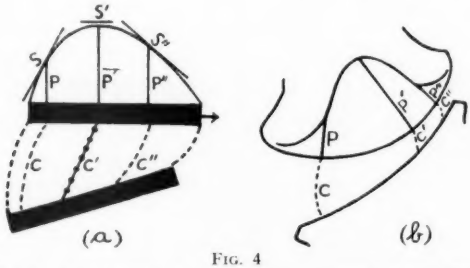

FIG. 4

Figure 4—(*a*) Distribution of counter-pressure in a convergent viscous film. The moving surface is taken as the "base of reference." C, C′, C″, the molecular strings (or columns) of the fluid, showing the change from positive curvature (C) through zero curvature (C′) to negative curvature (C″). P, P′, P″, the corresponding pressures on an arbitrary scale. S, S′, S″, the slopes (tangents) of the curve at points corresponding to P, P′, P″, and C, C′, C″ respectively. The slope changes in sign as does the curvature of the molecular strings. The diagram at (*b*) shows the same pressure curve referred to a curved moving surface instead of a flat one.

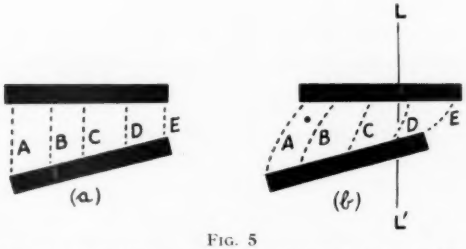

FIG. 5

A series of molecular strings of a viscous fluid (*a*) before movement, (*b*) during movement. Corresponding strings in the two instances are lettered alike. LL′: position of the resultant "load-line."

joints was first advanced by the present writer to correlate Walmsley's law of articular incongruity with the position of intra-articular discs and menisci (MacConaill 1932). Walmsley's law states that the articulating surfaces of a joint are incongruous except in one position special to each joint (Walmsley 1917, 1928): the position of congruity has been called the synarthrodial (or, close-packed) position by the writer. Previously, the opposite view was held, namely, that the discs and menisci increase the congruity of articulating surfaces in all positions. Later, Jones (1934) advanced the theory of viscous lubrication of joints independently; and in a further paper in 1936 he showed that the friction in a freshly excised finger joint was proportional to the speed of movement at its surfaces. Bruce and Walmsley (1937, 1938) showed that the menisci of the knee were replaced after excision under the stimulus of movement—a phenomenon in accordance with the function ascribed to them in theory. Finally Davies (1948) showed that this was the only known theory to explain the occurrence of certain intra-articular discs in the skate.

There is, then, a body of evidence both structural and experimental upon which it may be asserted, with some confidence, that the purpose of the synovial fluid and its ancillary mechanisms is to provide for lubrication by convergent films of the type described above.

THE NORMAL MECHANICAL PATTERN OF THE SYNOVIAL JOINTS

The normal mechanical pattern of a synovial joint, whether it be simple (finger) or complex (wrist, elbow), is shown in Figure 6. It consists of a pair of articulating surfaces, of which the male is of greater extent than the other (female) surface. One part of the male surface is always of the same curvature as the whole female surface (Fig. 3), and fits it point-for-point in the close-packed position: this is often the position of full extension, but not invariably so. Elsewhere the male surface has a smaller curvature than the female; thus we have the primary and essential incongruity of the two surfaces. The synovial fluid is present in greater amount than is strictly necessary for lubrication. But in the region of apposition of the joint surfaces the fluid is reduced in amount, and is kept suitably thin, by the interposition of fatty pads. It can be shown by experiment that these pads occupy regions where the fluid carried through in the direction of motion of the joint would break up into vortices, useless in, and even harmful to, the lubricant action of the fluid. It is well known that the fatty pad in front of the advancing surface recedes before it, while the pad behind that surface follows it in its course. In many joints—for example, elbow and knee—strips of muscle are inserted into the capsule to ensure this movement of the fatty pads. The fatty pads do not take any considerable pressure: that is the function of the fluid. They are liberally supplied with nerve endings, particularly of the pain-receptor type, and give rise to well-known symptoms when subjected to abnormal pressure. The fact that the synovial fluid travels in the direction of motion means that there is a kind of "circulation" within the joint. This enables the fluid to fulfil its nutritive functions more perfectly, and is one of the factors that account for the value of even moderate exercise in joints during rehabilitation.

FIG. 6

The lubricant apparatus of a typical synovial joint. M: moving surface. F: fixed surface. P, P': two fatty pads, which reduce the size of the extremities of the synovial film in the area of articulation.

The moving surface, in relation to the fixed, both glides and rotates. This has been shown by X-ray cinematography, which has given striking confirmation of the hypotheses of articular movement put forward by the anatomists of the nineteenth and early twentieth centuries. The rotary movement is, of course, more apparent to the eye in the case of the male surface; the gliding movement is the more obvious when it is the

female surface that moves. But both components are present in every case, and this has the result that the load-line does not pass through the same point of the moving surface throughout the movement: it travels in a direction opposite to that of the movement, and so also does the point of maximum pressure (Fig. 7). A wave of pressure travels, therefore, across the articular cartilage. Sometimes, if the movement be sudden and violent, the wave disrupts the cartilage, especially a thin and unsupported meniscus or disc, as in the knee.

When the joint is in the close-packed position the fluid is driven wholly from between the surfaces, which are then in full contact. It occupies the space between the capsule of the joint and the bevelled non-articular part of the cartilage. It is this bevelling that appears to provide the " port of entry " for the fluid which is to pass between the surfaces when movement starts again. The advantages of a similar bevelling have been recognised in engineering practice.

Finally, it may be mentioned again that the viscosity of the fluid is important. When it is reduced too much by irritative effusion into the joint, lubrication breaks down: we have what the motorist calls " seizure," and attrition of the opposed surfaces is made more probable. It is not the quantity but the quality of the fluid that matters. Naturally the flatter parts of the surfaces are the more liable to attrition. They are the parts that come into full contact in the close-packed position; and they are the parts where senile arthritis is most often discovered in the dissecting room: for example, the most anterior parts of the condyles of the femur, and the flattened surfaces of the clavicular joints.

FIG. 7

The synovial wave of counter-pressure impinging on articular surfaces. Continuous-line curve: " immediate " pressure. Broken-line curve: " previous " pressure during the same movement. Long arrow shows the motion of the moving part, short arrows the travel of the pressure waves.

INTRA-ARTICULAR CARTILAGES

Intra-articular discs or menisci are found in joints where three conditions are operative: 1) marked rotary movement about an axis perpendicular to the articular surfaces; 2) marked flatness in the surfaces; and 3) a force tending to bring the surfaces together during the rotary movement—when, that is, the movement is screw-like. The joints of the clavicle and the knee joint are typical examples of joints in which these conditions exist. These conditions constitute, however, only a special form of a more general one, namely, gliding of a flattened surface over another such surface. The temporo-mandibular joint is such a case.

The essential mechanical features of the intra-articular cartilage are these: 1) it is wedge-shaped in transverse section; and 2) it is hinged to the capsule (the cornual attachments of the menisci of the knee being developmental relics of such a hinge-like attachment). These two characteristics, combined, make it possible for the cartilage (meniscus) to take on a slight helical twist about its long axis. Moreover, because of the hinging to the capsule the inclination of the disc or meniscus to the moving articular surface can be varied slightly.

Between forty and fifty years ago an Australian engineer, Michell, took up the question of flat lubricated bearings (as distinct from the ordinary cylindrical shaft lying on a curved journal). Flat bearings are used to take the axial thrust of the rotating shafts of ships' propellors, hydro-electric generators and the like. In his day such bearings would " seize " at pressures across them as low as 60 lb./square inch, which is about half that across an average knee joint. This was because the bearing surfaces were parallel. Up till then, Reynolds' theory of lubrication had had no practical application. Michell invented a mechanism, the essence of which is shown in Figure 8. He put in a series of metal blocks between the fixed

and the moving surfaces. These blocks pivoted radially on the fixed surface, as shown in the diagram, and could therefore rock slightly. It was Michell's deduction from the theory of lubrication that the blocks would set themselves automatically to some angle with the moving surface as soon as rotation began; thus a convergent film—or rather a series of such films—would be formed, and the lubrication of the system would be assured. His deduction was justified, and the Michell thrust pad, as it is called, is a standard piece of engineering equipment

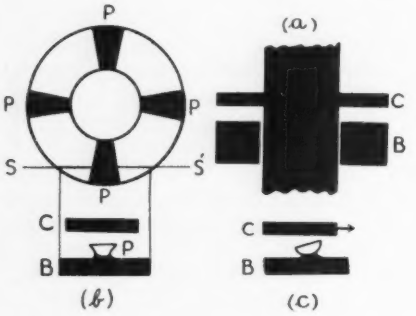

FIG. 8

The principle of the Michell thrust-block. (*a*) Longitudinal section of a rotating shaft with "collar," passing through a perforated thrust-block. (*b*) Plan and section of the same with four Michell thrust-pads inserted to take the pressure from the collar. (The section is taken through the plane S-S' of the plan.) B: bearing surface. C: collar. P: thrust-pad hinged to B. In this figure the parts are at rest. Sketch (*c*) shows the section in (*b*) with the parts in motion. The thrust-pad has automatically set itself at an angle to the collar to form a lubricant film, convergent in the direction of motion of the collar.

to-day. By its use, pressures of many hundreds of pounds to the square inch are easily carried for weeks at a time.

The menisci of the knee joint are nothing but a series of Michell thrust pads joined in continuity (Fig. 9). This is the "ideal" surface suggested to Michell by his own calculations; he showed further that such a surface should be capable of the helical twist mentioned above. Such a twist could not be permitted in a metal construction, for the torque would soon crack the block. But the structure of the menisci does allow of it, and our joints—so often thought to be imperfect—are, to that extent, better than those made by the best engineer. The intra-articular discs are merely more generalised forms of the same mechanism. The discs and menisci differ from the Michell thrust pads in that they themselves move relatively both to the moving surface and to the fixed surface. Indeed, the disc which has the greatest relative motion—the disc of the temporo-mandibular joint—has a special muscle to pull it forwards: the pterygo-capsularis, as it may be called. This is the so-called superficial head of the external pterygoid muscle; it is wholly inserted into the articular disc, its tendon fibres passing through the capsule and then fanning out in the substance of the disc. This is easily seen in cleared specimens viewed by polarised light.

The action of the intra-articular cartilages is, then, that they set themselves at a slight inclination to the flattened moving surface so that a convergent viscous film is set up in the region of the load-line of the joint. They increase the "mechanical curvature" of the system, being analagous to the flint-glass element inset into many crown-glass lenses to increase their converging power. Their action is to be contrasted with that of the fatty pads, which at first sight seem to be a softer form of the same device. The fatty pads, as has been mentioned above, are interposed between the more divergent parts of the articulating surfaces, and thus reduce the "mechanical curvature" so as to keep the thickness of the synovial film down to its useful limits.

Finally, mention must be made of the intrinsic structure of intra-articular menisci in relation to function. Their more peripheral parts are largely fibrous, and are covered by synovial membrane; they are vascular and have a rich nerve supply. Their more central parts are largely cartilaginous, and are devoid of synovial membrane; they are avascular and have no nerve supply. Direct observation shows that only the central parts take weight in the uninjured joint (MacConaill 1932); the effects of pressure upon the peripheral parts in an

injured joint are well known. Walmsley and Bruce (1938) have shown that the meniscus produced by regeneration after removal is essentially fibrous in structure. Mechanically, all that matters is that the meniscus should be both tough and deformable

For a more detailed account of the discs and menisci from the mechanical standpoint the reader is referred to two papers by the present writer (MacConaill 1932, 1944).

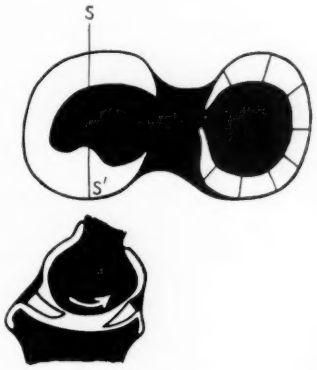

FIG. 9

Schematic plan and section of the menisci of the knee. The section is taken through the plane S-S' of the plan, and is shown in motion in the direction of the arrow. The lateral meniscus is shown as composed of a number of " Michell thrust-blocks " in continuity.

THE FUNCTION OF THE SESAMOID BONES

The preceding discussion may be summarised by saying that the synovial fluid, helped by the ancillary mechanisms of the fatty pads, the intra-articular cartilages and the general incongruity of the articular surfaces, takes the thrust of gravity or of any other centripetal force directed along the moving bone across the joint. It balances this force by a counter-pressure in accordance with the laws of hydrodynamics. But we may go further. It is a corollary to the theory of articular lubrication that every synovial joint is the seat of a pressure directed across its cavity between the fixed and the moving surfaces. It follows that the movement of a sesamoid bone sets up such a pressure. That is to say, part of the energy of contraction of the muscle whose tendon carried the sesamoid is converted into a thrust transverse to the direction of contraction. There is a kind of " bow-string " pressure in every sesamoid articulation. Thus, the quadriceps of the thigh exercises a bow-string pressure upon the lower end of the femur through the patella; and the flexor carpi ulnaris exercises a bow-string pressure upon the cuneiform (triquetral) bone of the carpus through the pisiform. Pressure of this kind may be termed *sesamoid pressure*. The sesamoid pressure is proportional to the speed of contraction of the muscle: this is a tested deduction from the theory of lubrication. The purpose of sesamoid pressure merits further inquiry. The example of the patella seems to indicate that it acts as a direct displacement force, pushing back the lower end of the femur when we move, for example, from sitting to standing; the slackness of the quadriceps femoris in complete extension of the (standing) knee is in conformity with this hypothesis. It is difficult to avoid the conclusion that many fractures of the patella, and of the cuneiform, are due to a sudden and violent rise in trans-articular pressure from spasm of the sesamoid-bearing muscles. The fact that the patella can be removed without appreciable loss of mechanical efficiency—as distinct from the risk of attrition of the reconstructed tendon—argues that bow-string pressure is an important function served by sesamoid bones.

SUMMARY

1. Synovial fluid acts mechanically by forming a convergent lubricant film between the fixed and the moving joint surfaces. This term and the underlying theory are explained.

2. The fatty pads assist lubrication by reducing the " mechanical curvature " in joints with more highly curved surfaces.
3. The intra-articular discs and menisci increase the " mechanical curvature " in joints with surfaces of small curvature.
4. Sesamoid bones exert a " bow-string pressure " upon the bones with which they articulate. This is a corollary from the theory of lubrication.

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FROM AN ATLAS OF GENERAL AFFECTIONS OF THE SKELETON

15. PAGET'S DISEASE

Synonym—Osteitis Deformans

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This chronic disease is characterised by slowly spreading changes in one or more bones, the changes consisting of decalcification coupled with hyperostosis and with the marrow spaces in the transformed bone occupied, partially or completely, by vascular fibrous tissue. Czerny (1873) suggested the name osteitis deformans, but ever since the publication in 1877 of Paget's paper, in which he described with characteristic lucidity the clinical features of eight cases, his name has been coupled universally with the disease. In 1908 Elmslie collected ninety cases and reviewed the whole subject, and in 1938 Brailsford discussed the changes in 154 cases which he had examined radiologically.

Hereditary and familial influences are evident in some cases. In seven of Elmslie's ninety cases other members of the family were affected. Since that date many instances have been recorded in parents and offspring, and of brothers and sisters. We have twice met with two brothers afflicted with this disease.

Age—The majority of cases are seen between fifty and seventy years of age. Though uncommon before the age of forty, several unquestionable cases have been diagnosed at thirty years. Since in some of these more than one bone was affected, the disease was unlikely to have been a recent development.

Sex—Males are rather more commonly affected than females.

Incidence—Paget's disease is one of the obscure diseases of the skeleton which are relatively common, many cases being discovered incidentally when investigated radiologically for symptoms entirely unconnected with the bone condition. Incidence figures most likely to approach accuracy are obtainable only from radiological departments. Inquiry some ten years ago from the radiologists of the teaching hospitals of London revealed that the average annual number of Paget cases seen at each hospital was approximately fifty.

Distribution—The disease may be confined to one bone, at least for a period of years. The tibia is a common site for a solitary lesion. Sooner or later in most cases several bones are affected: only exceptionally is the disease so widespread as to be almost generalised. Published lists of the bones most commonly affected, in order of frequency, vary, but they all agree in placing the pelvis at the head of the list. It showed changes in 243 cases out of a total of 367 reviewed by Dickson *et al.* (1945). The femur, tibia, lower spine and skull are all common sites. The humerus, clavicle and forearm bones are distinctly less common, while the hand and foot, with the possible exception of the tarsal bones, are seldom affected, a point in which the disease differs from polyostotic fibrous dysplasia. The ribs and the manubrium sterni —occasionally even the whole of the sternum—may be affected. When the skull is involved the facial bones very seldom show changes, an important point of difference from leontiasis ossea. In the tibia the changes spread from the upper end far more commonly than from the lower: the same is true of the femur. Changes may begin at both ends of a bone, but this is excessively uncommon.

The distribution appears to be almost entirely erratic, and shows little if any tendency to be symmetrical. When, however, the pelvis is involved there is a greater chance than otherwise of finding the upper end of one or both femora and the sacrum and lower spine also showing changes.

Etiology—The cause is unknown. The inflammatory hypothesis, making infection responsible, is now generally discarded. There is no endocrine error; the parathyroid glands are normal, and their removal in this disease is useless and unjustifiable. Disorder of mineral metabolism is suggested as the possible cause (Hunter 1948). Injury has been suspected of playing a part in the incidence of the disease in a few cases. In one patient, a man of thirty-seven years with typical Paget changes in a tibia, swelling of this bone had been present ever since an injury at the age of fourteen years.

Signs and symptoms—Though it is agreed that the changes in one or more bones are often no more than an incidental finding, there is considerable variation in the percentage said to have symptoms referable to the osseous lesions. Only 48 per cent. of eighty-two cases studied by Newman (1946) have symptoms closely related to the Paget's disease. He found that only 35 per cent. complained of pain, whereas Hunter (1948) stated that pain, usually in the back of the legs, was present in as many as 80 per cent. We find difficulty in accepting the latter figure if the cases discovered incidentally by the radiologists are included. The pain is of various types, occurs at various times of the day or night, and is provoked by a variety of causes. For instance, pain in a tibia may be worse in bed, or on walking may be concentrated at the limit of the changes in the bones. Headache is common and may be caused or exaggerated by exercise or coughing. Kay *et al.* (1934) found headache severe in eight of thirty-four cases. Spontaneous diminution or complete disappearance of pain may occur. Dickson *et al.* (1945) found backache in 119 cases, headache in sixty-four, and pain in the legs in fifty-eight of the 367 cases studied by them. Swelling and deformity may call attention to the disease when a tibia is involved, and increase in size of the head (necessitating repeated purchase of larger hats) is a frequent cause of complaint when the skull is affected. In a tibial case the overlying skin is often warmer than that on the other side, and occasionally it is even red or oedematous, but only quite exceptionally is tenderness present. An affected tibia is thickened, its anterior margin rounded, and the deformity further increased by antero-lateral bowing. Thickening of other affected bones and increase of their normal curves may be readily felt. When the upper part of the femur is affected signs of coxa vara may be present. Limitation of abduction at the hips may, however, be due to deepening of the socket or osteoarthritis in addition to coxa vara. In an advanced case, with many bones affected, the crouching or " simian " attitude assumed on standing may be suggestive. The large head is held low with the chin thrust forwards, the chest is flattened laterally, the spine is kyphotic and the legs are bowed antero-laterally with the joints slightly flexed. The reduction in stature resulting from deformities may be considerable: in one case (Osler, quoted by Lewin, 1922) the reduction amounted to thirteen inches, and even this was exceeded in a case reported by Hurwitz (1913). Though as a rule the curvature of a bone results in approximation of the ends, apparently authentic cases of lengthening have been observed: Elmslie (1908) stated that " numerous instances " had been recorded. We have seen a tibia which was three-quarters of an inch longer than the opposite normal bone. Another convincing case, with an elongated radius curving round a normal ulna, was published by Vilvandré (Kay *et al.* 1934). Fixed pronation deformity produced in this way was first called attention to by Symonds (1881). Fracture may be the initial occurrence, the bones most often affected being the femur and tibia. Deafness due to otosclerosis—not to pressure on the auditory nerve—is common, but only in those with the skull obviously affected (Jenkins 1923). Interference with vision, by pressure on the optic nerve, occurs much less often. Arterial degeneration is common in the older cases, often with retinal haemorrhages and choroidal changes. Calcareous arteries are frequently found—in as many as 40 per cent. of the cases according to Hunter (1948). We are inclined to doubt the statement that Paget's disease occurs with special frequency in those exhibiting premature senility.

Blood examination—The only constant change is the increase, often to as much as twenty or thirty times the normal, of the alkaline phosphatase, the amount varying roughly with the

severity of the disease. The acid phosphatase is increased only quite exceptionally. The serum calcium is normal in amount and so may be the plasma phosphorus, but this is often high. The excretion of calcium and phosphorus is increased, but the amounts have no relation to the severity of a case. Since the kidneys are taxed, hypercalcaemia may occur late in the course of the disease. Increase in the proportion of basophil and eosinophil cells is reported by Piney (1925). Glycosuria is present in some cases, the pituitary being suspected as possibly responsible.

Radiographic appearances—Excluding the skull, the changes in the bones may be divided into four types: 1) honeycombed or spongy; 2) striated; 3) dense; and 4) grossly cystic. Two or more of these may be found in a case, or even in a single bone. In the tibia, for instance, during the early years of the disease when it is slowly spreading, it is common to find a clear cyst-like appearance at the advancing point and honeycombed changes behind it. Generally speaking the honeycombed appearance is the commonest and most widespread. The next most common type is the striated, in which the trabeculations, standing out boldly, show a greater inclination to be parallel than those in the honeycombed type. Striation may be seen in any bone but more often, perhaps, in the pelvis, sacrum, vertebral bodies and calcaneum. Thurstan Holland (1925) called attention to the appearance of striation in the calcaneum while the bone was still apparently unaffected by the disease, and he regarded it as an early sign of some diagnostic value. The dense type is seen typically in the spine in some cases, the bodies of certain vertebrae showing uniform increased density, with little if any increase in size. If two or more vertebrae are affected they are not necessarily adjacent. It is a curious fact that if a vertebral body is dense, it is as a rule uniformly dense throughout. Apart from the advancing point of the disease seen typically in the tibia, as already mentioned, a grossly cystic appearance is uncommon: we have met with it in the fibula, the diagnosis being impossible until typical Paget changes were discovered in the opposite tibia and other bones. We have seen it also in the radius. Clear areas worthy of being called cystic are occasionally seen in the pelvis. Though there seems to be a preference in some cases for one particular type of change, there is general agreement that in most cases there is a tendency for affected bones to become denser in the course of time. The primary changes in the shaft of a long bone are essentially *in* the cortex, which appears to be partly or completely decalcified: new bone is formed both on the surface under the periosteum and towards the medulla, and later replaces, to a varying extent, the decalcified cortex. The diagnostic value of the pointed extremity of the changes in the shaft of a long bone has been appreciated for many years, attention being called to it, we believe, by the late Professor S. G. Shattock. The ends of the long bones are less commonly affected than the shafts but coarse trabeculation, for instance of a femoral condyle, may be the first sign of disease in the bone. In the pelvis the essential change may be increase in the density of the bone, but in our experience this is much less common than honeycombing. The pelvis may be indented, but this is also exceptional.

In the skull there is thickening of the outer table and irregular increased density. In a typical case the calvaria is considerably thickened, with the surface somewhat ill-defined and the bones coarsely mottled with dense rounded " nigger wool " spots of varying size. The sutures are obliterated. The changes are more likely to be generalised throughout the calvaria than in leontiasis, and are much less likely to involve the maxillae. In some cases clear areas are seen and these may be sufficiently marked to warrant the title of *osteoporosis circumscripta cranii*. Of forty-seven cases of this latter condition, thirty-two had Paget's disease in addition, and in eighteen of these both conditions were present in the skull (Kasabach and Gutman 1937). These authors suggested there was justification for regarding osteoporosis circumscripta as either an atypical form of Paget's disease or a precursor of it. There is no general agreement, however, as to the cause and nature of osteoporosis circumscripta: possibly it should be regarded as a clinical feature rather than as a clinical entity. Windholz (1945) suggests that it results from circulatory disturbance at the base of the skull caused by a variety of conditions.

There is no constant change in the pituitary fossa. The pineal gland may be calcified (Brailsford 1938).

The normal curve of an affected long bone is increased, and the deformity is accentuated by thickening on the convex side of the curve. Coxa vara may occur but this is often more apparent than real, the deformity as a rule occurring in the shaft of the bone. Arthritic lipping of the vertebral bodies is naturally common at the age at which Paget's disease is most frequently seen. According to Snapper (1949) the Paget changes begin in the lipping and spread to the body.

Fractures, if present, are abrupt, more or less transverse, and are seldom comminuted. Decalcification of the fragments in the region of the fracture may be so rapid and coarse that the presence of a malignant growth may be suspected. Multiple partial fractures are occasionally seen on the convex side of a curved bone (see below). Collapse of a vertebral body may occur but is uncommon.

Progress—In an individual long bone the changes steadily progress till the whole shaft is involved. Deformities also steadily increase for a time, but not indefinitely. The skull, when affected, gradually increases in size. Low diastolic pressure and cardiac failure are not infrequent in the later stages.

Complications—Fractures are not uncommon, and may occur with greater ease than normal, but it is doubtful whether they occur with much greater frequency than is usual in those of advanced age. Common sites are the upper third of the femoral shaft and the tibia a little below the head. Less common sites are the humerus, lower third of tibia, patella and pelvis. Pain after a fracture may be less than usual. Union takes place readily, but a fracture in the upper third of the tibia, often a horizontal crack with no displacement, produces minimal callus and may be slow in disappearing. Incomplete fractures sometimes occur and several may be seen in a single bone, but only in quite exceptional cases (Roberts and Cohen 1925, Allen and John 1937, Brailsford 1938, Dickson *et al.* 1945). The femur and tibia are the bones affected in this way: healing takes place with a minimum of callus. A partial fracture may become complete. Paraplegia due to hyperostosis of one or more vertebrae is very uncommon but certainly occurs. Urinary calculus was present in twenty-two of 367 cases (Dickson *et al.* 1945).

Sarcoma is a well-known complication of an advanced case, but we believe that the incidence has often been much exaggerated since the days of Paget. The frequency has been variously given as 2·4 per cent. (Newman 1946) up to 11 per cent. (Bird 1927). Dickson *et al.*, however, in their 367 cases found only three with sarcoma. Inquiry in 1938 from a dozen leading radiologists in London, many of whom were seeing a fresh case of Paget's disease almost every week, revealed that the number of cases with sarcoma seen by any single man in his life varied from one to five. There was one exception, a radiologist concerned, we believe, more with therapy than diagnosis, who regarded sarcomas as by no means a rarity. The fact that Platt (1947) had dealt with twelve cases of sarcoma occurring in Paget bones should be regarded as an indication of his reputation for exceptional knowledge and experience of bone tumours rather than as a true indication of the frequency of this complication. One of Platt's cases had multiple tumours of the skull: other similar cases have been reported. In patients over fifty years of age with sarcoma of the bone, a considerable proportion—28 per cent. according to Coley and Sharp (1931)—have Paget's disease in addition, both affecting the same bone. This complication is distinctly more common in males, and is seen most often when they are approaching the age of sixty, whereas the average age of all bone sarcomas is twenty-three years (Bird 1927). The new growth occurs only in a bone showing Paget changes, usually in a lesion of the osteolytic rather than the sclerotic type (Sear 1949). The simultaneous occurrence of sarcoma in more than one bone has been reported in several cases (Albertini 1928, Gerstel and Janker 1933, Davie and Cooke 1937). Of seventy-six collected cases of sarcoma complicating Paget's disease, twenty-six showed multiple bone involvement

(Summey and Pressly 1946). It is said that the multiple tumours in these cases are found only in bones affected by Paget's disease, and occur with far greater frequency than metastases to bone from osteogenic sarcomas generally. Sear (1949) reported the case of a man of forty-seven years with a metastasis in a normal rib. The bones affected, in order of frequency, in the forty-nine cases of Paget sarcoma studied by Davie and Cooke, were: the humerus, femur, skull, tibia and scapula; the radius, clavicle, pelvis and a vertebra were the site only of solitary tumours. Fracture may be the first indication of the presence of the neoplasm. In most cases the tumour is of the osteogenic type, but it may be a fibro- or chondro-sarcoma (Willis 1948). In three cases a malignant osteoclastoma was found (Russell 1949). In two cases reported by Davie and Cooke the oxyphil-cell content of the parathyroids was reduced.

Multiple myeloma co-existing with Paget's disease has been reported (Reich and Brodsky 1948). In one patient known to us, a man of fifty-three years, neurofibromatosis, Paget's disease and sarcoma of the pelvis were all present.

Pathology—Macroscopically a bone affected with Paget's disease is irregularly thickened, its surface markings and borders are obliterated, and the normal dense corticalis is replaced by spongy bone which is covered with red streaks and dots and is obviously abnormally vascular (Hunter 1948). On section much of the original bone is found to be replaced by newly formed spongy bone, the spaces in which may be filled with fibrous tissue. This fibrous tissue is less dense and more myxomatous-looking than that found in "osteitis fibrosa," while it is often extremely vascular. Resorption is less marked and the formation of new bone more marked than in von Recklinghausen's disease. There is a more even distribution of the new trabeculae, with no large areas of fibrosis (Knaggs 1925). Where absorption is taking place osteoclasts are abundant, but anything worthy of the name of osteoclastoma is seldom found. The new bone consists of very irregular lamellae closely applied to remnants of the old bone. The curvilinear cement lines stain deeply and are responsible for the typical mosaic appearance. Woven bone is exceptional. Calcium spheroids may be seen (Eden 1939). There are no cysts. In the skull there is thickening, irregular density and increased vascularity: the foramina may be reduced in size. The foramen magnum and the posterior fossa may be distorted. The thyroid has been reduced in size and the colloid found to be scanty in several cases. The parathyroids are not hypertrophied.

Diagnosis—The difficulties vary with the particular part involved. When several bones show changes the diagnosis should be easy. When only one bone or the skull alone is affected, care may be required. As regards the skull, a diagnosis of leontiasis is favoured by the localisation of the thickening to only part of the calvaria, by obvious involvement of the facial bones on at least one side, and by the absence of the gross type of mottling with woolly circular spots of dense bone so typical of Paget's disease. A meningioma may be associated with considerable hyperostosis of part of the calvaria (Rowbotham 1939). With the pelvis involved, particularly when the changes are of the dense type, secondary carcinomatosis from the breast or stomach, and particularly from the prostate in an elderly male, has to be excluded. Though metastatic infiltration of the pelvis may be associated with little if any thickening of the bones, distortion of the surface certainly may occur. In the case of a prostatic growth the abnormal amount of acid phosphatase in the blood may be conclusive. Fluorosis can produce marked increase in density, but more uniformly than that usually produced by Paget's disease. A dense vertebra can result from metastases from a carcinoma of the breast, and also may be seen in Hodgkins' disease (Dresser and Spencer 1936). In the case of a long bone, changes due to polyostotic fibrous dysplasia have to be excluded, particularly in the early stages, or when the Paget lesion is unusually cystic. In most cases one or more other bones will show changes typical of Paget's disease. Chronic infection may also give rise to difficulty in exceptional cases: syphilis is not likely to complicate matters in Britain nowadays. When hyperparathyroidism produces changes in the bones these are generalised, which is never so in Paget's disease. In Paget the honeycombing of a bone

is accompanied by new bone formation on the surface, whereas in hyperparathyroidism, if a bone is enlarged, the cortex is distended from within and reduced in thickness. In this condition the calvaria is decalcified and finely mottled, and shows little if any thickening.

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CASE 8—PAGET'S DISEASE

(Figs. 27 to 30.) Male, aged fifty years. First noticed head increasing in circumference at age of thirty-four years. Since that date the femora, tibiae, humeri, right clavicle, right ulna and, to a less extent, the radius have become thickened. Now complaining of shortness of breath and " tumour of the stomach." Head enormous, suggestive of hydrocephalus. Has marked kyphosis and much thickening of some ribs. Bones of both upper and lower limbs bowed. His liver, pushed forwards and downwards, forms the " tumour " complained of. Mitral regurgitation. Arterio-sclerosis. Blood examination normal. Wassermann negative. Advanced changes typical of Paget's disease in the skull, most of the major long bones, pelvis and ribs. (Under Sir Cecil Wakeley.)

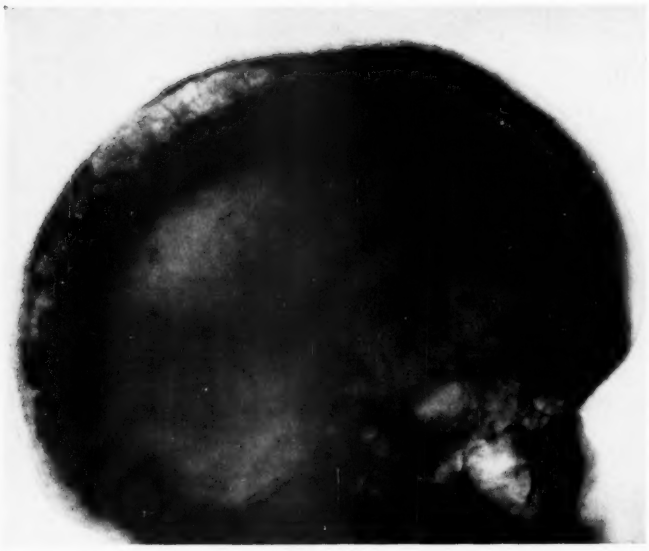

FIG. 27

FIG. 28

Case 8—Figure 27, skull showing gross increase in thickness—one and five-eighths inches in an unreduced radiograph—of whole calvaria, but not of base. Fairly typical mottling. Figure 28, right arm showing honeycombed type of disease in humerus and ulna and some atypical change in the radius.

FIG. 29

Case 8—Left side of pelvis and femur, showing advanced changes of mixed honeycombed and striated types, and marked bowing of femur.

FIG. 30

Case 8—Knee joint showing typical changes in all three bones.

CASE 9—PAGET'S DISEASE

(Figs. 31 and 32.) Male, aged sixty-five years. Had rickets in infancy. Fifteen years ago noticed hats were small after a year's wear. Head stopped growing two years ago. Has lost two and a half inches in height. General health good. Head large and lumpy on top. Right clavicle enlarged and right iliac crest thickened. Kypho-scoliosis rather marked, with reduction of mobility. Considerable limitation of movement of hips except flexion. Slight general bowing of legs: no obvious thickening. Skull, pelvis and lower spine show typical changes. Left tibia shows very early disease below the tubercle. Pelvis is deformed. Diagnosed as Paget's disease five years ago.

FIG. 31

FIG. 32

Case 9—Figure 31, left tibia showing very early Paget changes in the region of the tubercle. Note the area of decalcification with a pointed lower extremity *in* the anterior cortex. Figure 32, pelvis and upper femora show Paget changes of various types including increased density. Note pelvis is deformed.

CASE 10—PAGET'S DISEASE

(Fig. 33.) Male, aged forty-two years. Complained of pain in left tibia for past six months. Swelling appeared recently. Slightly irregular swelling, tender at lower end, of subcutaneous surface of upper third of tibia. No other bone lesions discovered. Wassermann negative.

Early Paget's disease suggested as possible diagnosis by the late Sir Watson Cheyne. Sixteen years later further investigations revealed typical changes in the skull, tibiae, femora and other bones. Had suffered little pain during the intervening years.

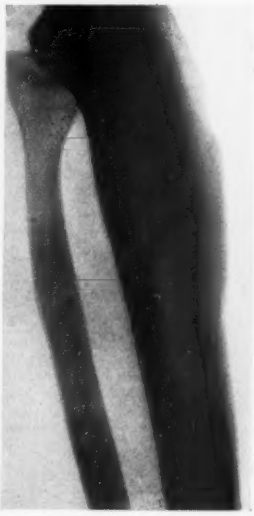

FIG. 33

Case 10—Left tibia showing early Paget changes with typical pointed lower extremity *in* the cortex, but with unusually uniform density. Compare with Figure 31. Note early Paget changes in the fibula.

CASE 11—PAGET'S DISEASE

(Fig. 34.) Male, aged seventy-three years. Swelling of upper half of tibia for past few years. Typical Paget changes. Remainder of skeleton not investigated radiologically.

FIG. 34

Case 11—Leg showing typical Paget changes in the tibia. Note the pointed lower extremity below and mottled increased density with some honeycombing above, and the calcified arteries. For comparison with the earlier lesions seen in Figures 31 and 33.

CASE 12—PAGET'S DISEASE

(Fig. 35.) Male, aged forty-six years. Complains of headache and bronchitis for past eight months. Frontal headache especially on coughing and on certain movements of head and neck. No pain elsewhere. Slight deafness. No obvious thickening of skull. Nature of disease confirmed by biopsy of skull. Decompression operation had failed to relieve headache. Typical changes seen in films of skull, pelvis, sacrum, lower spine and upper ends of femora.

FIG. 35

Case 12—Pelvis and upper femora, showing mixed changes of the striated and honeycombed types. Vertical striation in lumbar bodies present but not well seen.

CASE 13—PAGET'S DISEASE

(Fig. 36.) Female, aged seventy years. Complained of pain at bottom of back and in knees for past five years. Worse after sitting. Marked kyphosis. Pigeon breast. Atheroma. Deafness. Bowing of femora and tibiae. Typical Paget changes in pelvis, both femora, humeri, radii and ulnae, one tibia and fibula, and the lower dorsal and lumbar vertebrae. One foot shows marked striation without new bone formation except a little on the calcaneum. In the arms increased density and thickening are the chief features: a " cyst " is present in the upper third of one humerus.

FIG. 36

Case 13—Foot showing generalised striation of the bones. No hyperostosis present except on inferior surface of calcaneum.

CASE 14—PAGET'S DISEASE

(Figs. 37 to 39.) Male, aged fifty-two years. Admitted for fracture of left humerus in lower third: had sustained a fracture of the upper third of this bone eleven years previously, at which time the bone was considered to be abnormal. Said to have fractured odontoid process of axis vertebra when thirty-one years of age: this vertebra is now abnormal. Changes in bones of legs noticed for past four years. Wassermann negative. Serum calcium 10·5 milligrammes and plasma phosphorus 3·8 milligrammes per 100 cubic centimetres. B.S.R.—normal. Urine—normal. Typical changes found in skull, both humeri, pelvis and both femora, right tibia and upper third of left fibula. The fibular lesion is unusually cystic in appearance. (Under Mr A. Compton and Dr F. Parkes Weber.)

FIG. 37

Case 14—Typical Paget changes in the lower end of the femur and in the tibia of the right leg, and atypical cystic enlargement of the upper third of the left fibula.

FIG. 38

FIG. 39

Case 14—Figure 38, left humerus showing a recent fracture. Note that the disease has invaded the mid-shaft and the lower extremity of the bone leaving the intermediate portion of the shaft almost unchanged. Figure 39, skull and upper cervical vertebrae showing changes in the axis vertebra as well as in the greater part of the calvaria.

CASE 15—PAGET'S DISEASE

(Fig. 40.) Female, aged fifty-eight years. Fell while attempting to hang curtains. Admitted to hospital with fractured femur which was the seat of Paget changes.

FIG. 40

Case 15—Left femur enlarged by Paget's disease, and with a typical transverse fracture at the usual site.

CASE 16—PAGET'S DISEASE

(Fig. 41.) Female, aged forty-six years. Unusual case with facial bones involved. Operation for dental cyst thirteen years ago. Several subsequent operations on upper jaws. Complains of aching in left maxilla at times. Slightly deaf. Whole skeleton radiographed, but no bone affected other then the skull and superior maxillae. (By courtesy of Sir Frank Colyer.)

FIG. 41

Case 16—Skull showing typical Paget changes and also increased density of the maxillae. Note that the changes in the jaw are completely separate from those in the skull, a point against a diagnosis of leontiasis ossea.

CASE 17—PAGET'S DISEASE and OSTEOPOROSIS CIRCUMSCRIPTA

(Figs. 42 and 43.) Female, aged sixty-six years. Complaining of increasing enlargement of upper part of skull on left side, during past four months. Radiographs showed typical Paget changes in the skull, both ischia, right ilium, and several vertebral bodies. Osteoporosis circumscripta also seen in the skull. Wassermann negative. Serum calcium 10·4 milligrammes per 100 cubic centimetres. Two sisters of this patient also suffered from Paget's disease. (Under Dr H. Rast and Dr F. Parkes Weber.) (British Medical Journal, 1937; **1**, 918.)

FIG. 42

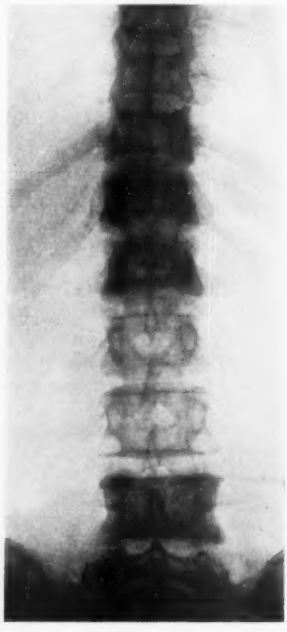

FIG. 43

Case 17—In Figure 42, the skull shows somewhat irregular but considerable thickening with typical coarse mottling and a sharply defined area of decalcification in the frontal region—osteoporosis circumscripta. In Figure 43, the spine shows increased density of certain vertebral bodies. Note irregular distribution of changes and fairly uniform density of the bodies affected.

CASE 18—PAGET'S DISEASE complicated by SARCOMA

(Figs. 44 to 46.) Female, aged seventy-six years. Gradual onset of pain in left groin during past four months, not affected by rest or exercise. Pain much aggravated by a recent fall. All movements of left hip limited by severe pain. Indefinite swelling in left groin; skin temperature raised; veins prominent; femoral artery pushed forwards by the swelling. Alkaline phosphatase in blood raised. No evidence of Paget's disease in any bone except the pelvis. Radiograph of chest shows left ventricular enlargement but no sign of metastases. Treated with Coley's fluid and X-ray therapy without benefit. Swelling increased. Numerous metastases appeared in the lungs, with left pleural effusion, and she died four months after first examination. Microscopic section confirmed the diagnosis of Paget's disease, and showed the growth to be a chondrosarcoma. (Under Mr S. A. Jenkins.)

FIG. 44

Case 18—Pelvis and hips showing irregular increased density of left side of pelvis with signs of sarcomatous growth in the ilium.

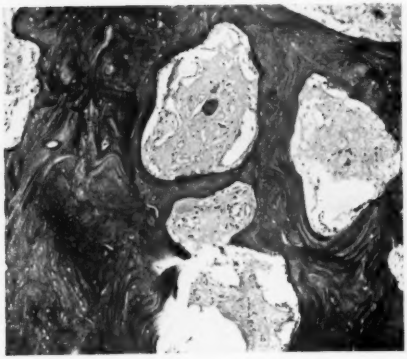

FIG. 45

FIG. 46

Case 18—Figure 45, a microscopic section of fragment from the pelvis, shows the typical mosaic structure of the bone, and the marrow spaces filled with loose myxomatous fibrous tissues (×50). Figure 46 is a microscopic section from the tumour area showing the chondrosarcomatous nature of the pelvic growth (×50).

FROM AN ATLAS OF GENERAL AFFECTIONS OF THE SKELETON

16. NEUROFIBROMATOSIS

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This is a congenital affection characterised by pigmented spots on the skin, cutaneous fibromata, multiple neurofibromata of the cranial and peripheral nerves, and, in some cases, skeletal changes, endocrine syndromes and " heterogeneous tumour formation " of the nervous system. According to Kinnier Wilson (1940), it was first described by R. W. Smith in 1849. In 1882 the histology was discussed by von Recklinghausen whose name is still attached to the disease by many. Valuable accounts of the skeletal changes were published by Brooks and Lehman (1924) and Holt and Wright (1948), and in children by Leader and Grand (1932). In tuberous sclerosis, a rare condition possibly allied to neurofibromatosis (Weber 1924), bone lesions have also been described (Heublein *et al.* 1940 and Ackermann 1944).

Hereditary and familial influences are in evidence not uncommonly. It has been seen in six generations (Gardner and Turner 1940). Four brothers showing signs of the condition were reported by Garland (1941).

Age—It is seen at all ages. Since at least some skin lesions are present at birth the condition may be recognised within the first few months of life. In some cases there appears to be an exacerbation at puberty.

Sex—Males are rather more frequently affected than females.

Etiology—It is considered to be a congenital anomaly due to defective germ plasm, but the cause is entirely unknown. Trotter (1926) suggested that faulty insulation of nerve fibres was responsible.

Clinical signs—In most cases typical lesions in the skin are present and the diagnosis is obvious. The skin lesions are of two kinds, café-au-lait spots or freckles and fibromata. The pigmented spots have smooth outlines and vary in size from a pin head to a five-shilling piece, but occasionally they are much larger. They tend to increase in size and number as the child grows. The distribution varies, but in some cases this is limited to the region of the pelvis and adjacent parts of the trunk and thighs. The cutaneous fibromata (fibroma molluscum) are either flat or raised. The colour may be that of the surrounding skin or it may be pink, violet or blue. They are of all shapes and sizes from a millet seed to an orange. Some present as a fold: others are pedunculated. They are soft and may feel like a bag of worms. There may be thousands present covering the entire body. Usually they are symptomless. The fibromata of nerve trunks may be in, on, or loosely attached to the nerves. They may be confluent. Those that are subcutaneous or reasonably accessible can be readily felt. They may be painful or tender, even sufficiently tender to produce protective spasm. There may be a plexiform neuroma, pachydermatocele or elephantiasis of a limb: in each of these conditions a bone in the vicinity not uncommonly shows radiographic changes. The nervous syndromes met with naturally vary with the locality of the fibromata. Tumours of cranial and spinal nerves, or of the cord or brain, give rise to a variety of symptoms, even to a sensori-motor paraplegia.

As in other conditions, the syndrome may be incomplete, the lesions being confined to the skin, or to the nerves, or they may be entirely central.

The skeletal affections are of two kinds—scoliosis and changes in the bones. Scoliosis is by far the commoner, occurring in about half of the cases. The part most commonly affected primarily is the lower dorsal region, but it may begin in the cervical. It is often associated

with some kyphosis, and is definitely progressive. Pain may be a troublesome feature. In advanced cases the rotation of the vertebrae is marked, and the curves are very abrupt. Paraplegia has actually resulted from the severity of the deformity alone (Miller 1936).

Changes in the bones, said to occur in 7 per cent. of the cases (Reuben 1934), are usually free from symptoms. Skin and bone lesions may be superimposed. They may be associated with either diminution or accentuation of growth of a bone: the latter is more common and is rarely seen without soft tissue changes in the neighbourhood. Only exceptionally do changes in the bone lead to a fracture and pseudarthrosis. Bowing of a tibia may precede pseudarthrosis, and the bowing may even be present at birth (Holt and Wright 1948). General asymmetry of the face, body and limbs with unilateral distribution of the bone changes was described by Friedman (1944). Cases with neurofibromata affecting the viscera have been described.

Blood examination gives negative results.

Radiological appearances—In most cases the scoliosis is unaccompanied by obvious lesions in the vertebrae. There may, however, be " cystic " changes in the bones (Capener 1935, Seddon 1935). Collapse of a body may occur. Erosion of the bodies from behind or enlargement of the intervertebral foramina may result from pressure by neurofibromata of spinal nerves. In a case published by Pugh (1930) there was an open clear wedge in the mid-dorsal region on the convex side of the curve, suggesting that an intervertebral space had gaped.

In other parts of the skeleton a variety of changes may be seen. A periosteal neurofibroma may cause smooth erosion of the cortex: in such a case a thin shell of bone is occasionally formed by the periosteum over the fibroma, the appearance being that of a cortical " cyst." The bone adjacent to a cortical erosion usually shows increased density which may be widespread. There may be " cystic " lesions *in* a long bone, but some which are apparently endosteal are really cortical in origin. A case with a large smooth excavation in the left ilium and complete disappearance of the horizontal ramus of the right pubis was reported by Heublein *et al.* (1940). Curious multiple cystic changes in the metaphyses of several of the long bones (the appearance being a little suggestive of dyschondroplasia), with the mandible and one vertebra also involved, were reported in an infant by Holt and Wright (1948). In another case published by these authors (a girl of four months) with less marked changes, the bone lesions disappeared completely. Increased density of the shaft of a bone may occur with no obvious erosion of the surface by an adjacent fibroma: this increased density often ends in streaks towards one end of a bone. Occasionally irregular thickening of a bone is seen. As already stated, an affected bone may be shorter or longer than its fellow. Tanner (1946) reported a case with a large neurofibromatous tumour adherent to the bones on the front of the leg, and with the tibia (but not the fibula) four and a half centimetres longer than the other and showing extensive irregular sclerotic changes in a radiograph. A somewhat similar case with the periosteum over the tibia greatly thickened was reported by Weber and Perdrau (1930). The ribs and the mandible sometimes show changes. An osteomalacic condition, particularly affecting the ribs, has been reported by Gould (1918), and multiple incomplete fractures by Brailsford (1948).

Associated with elephantiasis, two types of osseous change may be found affecting one or more of the bones—increase in both density and length and diminution of calibre without other structural change. Brooks and Lehman (1924) reported a case in which one tibia was eight centimetres longer than its fellow. In a case reported by Friedman (1944), a man aged thirty-one years with elephantiasis of one leg below the knee, there were several smooth indentations on the anterior surface of the tibia and considerable dense thickening of the bone: the affected leg was three centimetres longer than the other. The shafts of the humerus, radius and ulna were curiously slender in an arm affected by elephantiasis in one patient, and long thin metatarsals were seen in the foot of another: after amputation of this foot the fibula became attenuated (Holt and Wright 1948). In a third case published by these authors

similar changes were found in a clavicle and some ribs after removal of a supraclavicular neurofibroma. Slender bones may, however, occur without obvious changes in the soft tissues. A long thin humerus, associated with clear bulbous ends to each of the three bones forming the elbow joint, which was dislocated, was noted by Mondor and Leger (1946). In one case we found curious sharp lipping of the margins of the great trochanters and the ilia, a feature we have not seen reported by others (Fairbank 1939). The skull may show patches of either increased or decreased thickness, but these are exceptional. Increased density suggestive of leontiasis, but without thickening, we found in one case. Erosion of the occipital and petrous bones associated with a tumour of the auditory nerve was reported by Camp (1929). The pituitary fossa may be enlarged but as a rule it is normal.

Progress—The various types of lesion, skeletal and other, may or may not be progressive. The scoliosis, however, usually shows a tendency towards progressive increase of the curves, in spite of careful conservative treatment, and may eventually cause severe or complete crippling—an important fact to keep in mind when treatment is under consideration.

Complications—Paraplegia may develop in cases with severe scoliosis, even in childhood: as already mentioned it may also result when fibromata develop on spinal nerves. Complications arising from endocrine errors include acromegaly—three such cases were reported by Tucker (1924)—and hyperparathyroidism. It has been suggested that occasionally the two conditions described by von Recklinghausen, neurofibromatosis and hyperparathyroidism, are associated (Stalmann 1933, Cohen and Douady 1936). Sarcoma undoubtedly develops in some cases, but the frequency is uncertain: 12 per cent. is the figure given by Hosoi (1931) and 5·5 per cent. by Holt and Wright (1948). Neurofibromatous tissue was found in a tibia adjacent to a definite sarcoma of the bone (Norley *et al.* 1945). Sarcomatous change may occur in more than one fibroma (Miller 1936). Neurofibromatosis, Paget's disease and sarcoma of the pelvis were associated in one case known to us, a man of fifty-three years.

Mental deficiency and syringomyelia have been reported in association with neurofibromatosis.

Pathology—The neurofibromata consist of reticular connective tissue, with a few nerve fibres—myelinate or amyelinate—winding about either singly or in thin bundles. In places are seen cells " with long hair-like tails," arranged in sheaves or palisades, and proved by stains to be collagenous and fibro-glial. Hyaline degeneration of the connective tissues precedes jelly-like deposits—the cyst-like lesions—into which haemorrhage may occur (Kinnier Wilson 1940). In plexiform neuromata and elephantiasis there is loose connective tissue containing nerve strands " fantastically overgrown." The skin tumours are practically pure fibromata: only a small proportion include nerve fibres.

As to the bone lesions, the neurogenic origin of those which are subperiosteal is readily acceptable, but this is not so with those which are endosteal. Nevertheless the typical fibrosis with " whorls " of cells has been found in some lesions apparently endosteal. Uhlman and Grossman (1940) found " whorls " both in a soft tissue tumour and in the underlying cystic jaw of a girl of sixteen years. An intra-osseous neurofibroma was found at the site of a spontaneous fracture of the tibia in a girl of seven years (Green and Rudo 1943) and, as already referred to, in a leg amputated for sarcoma (Norley *et al.* 1945). Neurofibromatous tissue may or may not be found at the site of a pseudarthrosis.

We have discovered no clear statement as to the nature of the pathological changes in a bone showing diffuse increased density with neither cyst formation nor erosion of the cortex by a subperiosteal neurofibroma: Tanner (1946) considers that sclerosis is a late development and follows earlier rarefaction and softening. Collagenous and myxomatous degeneration in osseous lesions, with formation of cysts containing brownish fluid (the result of haemorrhage) are mentioned by Thannhauser (1944).

The cause of the scoliosis where there is no cystic or other lesion in a vertebral body is

obscure. There is usually no definite evidence of paralysis, but this may occur when a spinal root is the seat of a neurofibroma. Eden (1941) reported a case with multiple " dumb-bell tumours " of the posterior roots. In ordinary cases he likens the scoliosis to that seen in syringomyelia. It has been suggested that the deformity is due to derangement of tonic nervous control of the vertebral muscles.

Diagnosis—This should present little difficulty. The cutaneous nodules and subcutaneous neurofibromata should distinguish neurofibromatosis from polyostotic fibrous dysplasia with areas of pigmentation. These areas are smooth and generally much larger than the café-au-lait spots of neurofibromatosis. The bone changes may be somewhat similar.

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CASE 19—NEUROFIBROMATOSIS

(Figs. 47 to 49.) Female, aged twenty-one years. Complained of shooting pains, from the little toe up the back of the right leg to the hip, for the previous ten weeks. Pain not affected by exercise or rest. Swelling at back of right thigh as long as she could remember: painless until present attack. Pigmented areas of skin present since birth. Family history, negative. On examination—dark-skinned woman. Pigmentation on outer side of right ankle, back of

leg, whole of thigh, and both buttocks extending forwards on to abdomen. On the pigmented area of thigh there were circular black spots. Hairy mole on left buttock. Pigmented spots on chest and arms and pigmented patch on left ankle. Pain confined to pigmented area of right leg. Swelling on back of right thigh felt like a loose bag of skin, partially filled with fat containing hard round masses. Liver slightly enlarged. Diminished sensibility to pinprick in the area corresponding to the pain. Mild scoliosis. Temperature swinging to 100 degrees. Radiographs showed increased density of the shafts of the major long bones of the right leg, especially the femur, in which the density ends below in streaks. A cortical indentation is seen on the inner side of the upper third of the shaft of this femur, possibly the site of a periosteal neurofibroma. The lumbar vertebral bodies are relatively deep, and the transverse processes more slender than usual. (Under the late Dr Douglas Firth.)

FIG. 47

FIG 48.

FIG. 49

Case 19. Figure 47—Pelvis and hips, showing the slender pubic and ischial rami, sharp lipping of the lower margin of the right anterior superior iliac spine and of the margins of the great trochanters. Note the narrow joint space of the right hip, the exuberant rounded lipping on the femoral head and also on the lesser trochanter. Figure 48—Right femur and knee joint, showing distortion of the posterior surface of the shaft, and increased density, ending below in streaks. Note indentation of the cortex on the inner side of the upper third of the femoral shaft, and a suggestion of abnormal density in the tibia. Figure 49, Lumbar spine showing the vertebral bodies relatively deep and the transverse processes more slender and spicular than usual.

METHOD OF INSERTING THE SMITH-PETERSEN GUIDE WIRE

JOHN CHARNLEY, MANCHESTER, ENGLAND

Numerous methods have been advocated for the accurate placing of a guide wire in treating fractures of the neck and femur with the Smith-Petersen nail. In many parts of Great Britain, mechanical assistance has been abandoned in favour of the simple procedure advocated by Watson-Jones (1943). A stiff two-millimetre guide wire is passed into the neck of the femur by the sense of touch and, if the position is not satisfactory, a second wire is passed while the first is still in position to give the direction in which correction is required. This method has the advantage over elaborate mechanical methods in depending solely upon skill; and as skill is acquired with practice, a consistent level of accuracy can be achieved. Mechanical devices, designed to eliminate the element of skill, are prone to erratic results from factors, such as X-ray parallax, which the operator may not fully understand.

In the technique of Watson-Jones it is difficult to pass the second wire at a very small angle to the first, because the part of the wire which projects from the bone is often deflected by the chuck holding the second wire; when the chuck is removed, the second wire is found to spring into a quite unexpected direction. At each new venture the wire tends to re-enter the original track. The simple instrument here described eliminates this source of error, without removing the element of skill.

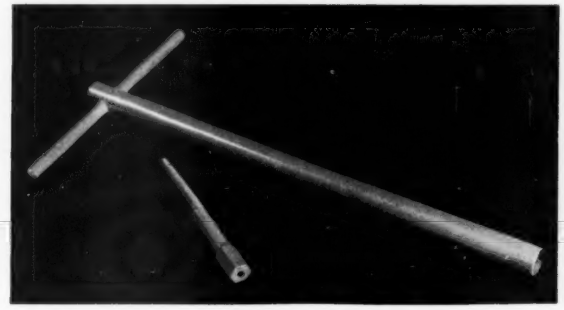

FIG. 1

Cannulated screw with tapering thread, and long-handled box-spanner fitting the hexagonal head.

Technique—The instruments required are : 1) a cannulated screw with a tapering thread, and 2) a long-handled box-spanner to fit the hexagonal head of the cannulated screw (Fig. 1).

The fracture is reduced, and the trochanter is exposed. At a point three-quarters of an inch to one inch below its lower margin, a three-sixteenth inch hole is made through the cortex of the femur in the estimated direction of the axis of the femoral neck; that is, towards a point one inch cephalad to the opposite anterior-superior iliac spine with the affected thigh abducted about 10 degrees. The cannulated screw, mounted in the long-handled spanner, is thrust into the drill hole in the same direction and parallel with the floor; and the spanner is rotated until the tapering thread is gripped in the hole. The spanner is then detached and a guide wire is driven down the central cannula. Radiographs are taken in two planes. If it is necessary to alter the direction of the wire an estimate of the correction required is made by eye. The wire is withdrawn and the spanner is carefully reattached to the hexagonal

head of the screw. The spanner, and with it the screw, is now forcibly deflected into the new direction and rotated so that the screw-threads grip the cortex in the new direction. The spanner is detached, the two-millimetre wire is again inserted and the new position is checked by radiographs. Three or four attempts would be possible before all the screw-threads became engaged, but in the author's experience it has never been necessary to make more than two attempts.

Measuring the length of the nail required—The required length of nail may be calculated from the antero-posterior radiograph if this includes the whole length of the shadow of the cannulated screw. The tube should be centred slightly lateral to the femoral neck to avoid excessive magnification of the screw in the lateral rays of the tube. By measurement of the shadow of the three-inch screw on the radiograph, the magnification is determined. The length of the nail required is estimated by making direct measurements on the magnified shadow of the femoral neck and reading off the correct length from a chart (Fig. 2).

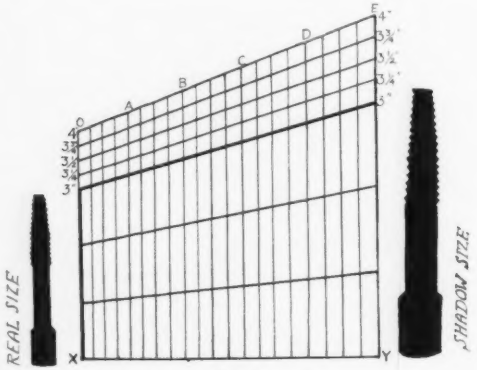

FIG 2

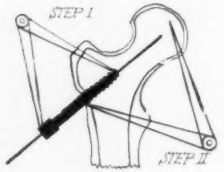

FIG. 3

Chart for converting magnified into real dimensions and vice versa (Fig 2). The sketch representing a wet radiograph (Fig. 3) shows two steps in calculating the required length of nail: the first step is to find the magnification of a known length, the second to convert the optimal (magnified) length to real dimensions.

Technique—The caliper is set to the length of the shadow of the screw on the wet radiograph (Fig. 3). This dimension is then compared with the chart where the magnifications are indicated by the vertical lines. Supposing the caliper corresponds to magnification B, then all subsequent measurements are confined to this vertical line. The caliper is reapplied to the wet film, this time to span the optimal length of head and neck to be gripped by the nail. The caliper is now transferred to the chart. One leg of the caliper is placed on the base line at the foot of the vertical line B and the other leg will touch one of the oblique lines designated $3\frac{1}{2}''$, $3\frac{1}{2}''$, $3\frac{3}{4}''$, $4''$ (etc.). This will be the length of nail required.

These instruments and copies of the calibration chart have been made for me by Messrs Charles Thackray Ltd., Leeds.

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VARIABLE SCALE FOR MEASURING FROM RADIOGRAPHS IN SMITH-PETERSEN NAILING

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The magnification of the radiographic image, though often of little consequence in nailing the fractured femoral neck, may lead to important errors in nailing the hip to promote arthrodesis. The use of a graduated measure that can be calibrated to the correct scale relieves the surgeon of mental arithmetic. Such a device is shown in Figure 1.

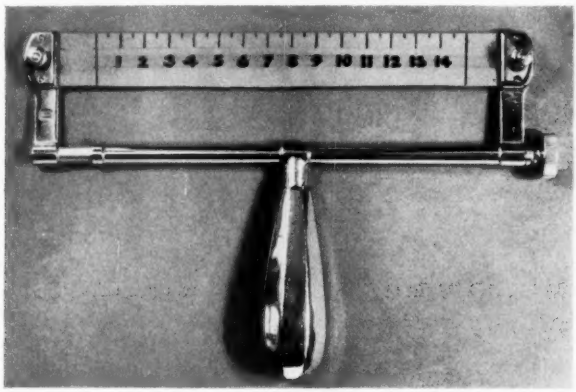

FIG. 1

In this instrument a metric scale has been drawn on rubber strip. Turning the milled screw causes the rubber to be stretched; the instrument is correctly calibrated when the magnified image of a known length can be measured directly on the expanded scale.

It consists simply of a strip of stout tourniquet rubber, bearing centimetre and half-centimetre graduations and carried in a frame which can be extended telescopically by means of a milled screw-head. The rubber, being approximately uniform in composition, width and thickness, is almost equally extensible throughout its length. At operation, a guide is introduced in a horizontal plane to a known depth, and a radiograph is taken on a horizontal film. The scale is laid along the radiographic image of the guide and expanded until it correctly records the known length of the buried part. For instance, if the guide has been introduced for a distance of ten centimetres, the scale is extended until ten "expanded centimetres" on the scale correspond with the enlarged image on the film. In this way the scale is correctly calibrated for reading directly from the film in units equivalent to real centimetres in the body.

This instrument was made for me by the Genito-Urinary Manufacturing Company, Devonshire Street, London, W. 1, and was described in a paper written with Mr E. T. Bailey in 1939.

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ORTHOPAEDIC SURGERY IN THE SIXTEENTH AND SEVENTEENTH CENTURIES

LUXATIONS OF THE HIP

WILLIAM BROCKBANK and D. LL. GRIFFITHS, MANCHESTER, ENGLAND

From the Medical Library of the University of Manchester

Ambroise Paré (1510–1590) is no less interesting on the subject of dislocations of the hip than he is in dealing with dislocations of the shoulder and of the spine. He seems to have included congenital and acquired dislocations and, most certainly, some examples of fracture of the neck of the femur. The first clear description of the pathology of congenital dislocation of the hip was not to come for 300 years after Paré wrote his account in 1575. The following paragraphs are reprinted from the English translation dated 1678.

OF A DISLOCATED THIGH OR HIP

" The thigh or hip may be dislocated, and fall forth towards all the four parts but most frequently inwards, next to that outwards, but very seldom either forwards or backwards. If the hip be dislocated towards the inner part that leg becomes longer and larger than the other, but the knee appears somewhat lower, and looks outwardly with the whole foot, neither can the patient stand upon his leg. To conclude, the head of the thigh bone betrays itself lying in the groin, with a swelling manifest both to the eye and hand. The leg cannot be bended towards the groin for that the dislocated bone holds the extending muscles of the same part so stiffly stretched out that they cannot yield or apply themselves to the benders.

PROGNOSTICS BELONGING TO A DISLOCATED HIP

" There is this danger in the dislocation of the hip that either the bone cannot be put into the place again, at least unless with much trouble, or else being put in that it will presently fall out again.

OF RESTORING THE THIGH BONE DISLOCATED INWARDS

" It is fit to place the patient upon a table or bench, in the midst whereof shall stand fastened a wooden pin of a foot's length and as thick as the handle of a spade but it must be wrapped about with some cloth, lest the hardness hurt the buttocks betwixt which it must stand. The wooden pin hath this use to hold the body that it may not follow him that draweth or extendeth it; and that the extension being made as much as is requisite it may go between the Peritoneum (*sic*) and the head of the dislocated thigh. For thus there is no great need of counter extension towards the upward parts. But when the extension hath need of counter-extension then it is needful you have such ligatures at hand as we have mentioned in the restoring of a dislocated shoulder, to be drawn above the shoulder. One of these shall be fastened above the joint of the hip, and extended by a strong man. Another shall be cast above the knee by another with the like force. Some too clownish and ignorant knot-knitters fasten the lower ligature below the ankle and thus the joynts of the foot and knee are more extended than that of the hip or knuckle-bone, for they are nearer to the ligature and consequently to the active force. But if the hands shall not be sufficient for this work then must you make use of engines. Wherefore then the patient being placed as is fit and the affected part firmly held, some round thing shall be put into the groin, and the patient's knees, together with his whole leg, shall be drawn violently inwards towards the other leg. And in the meanwhile the head of the thigh shall be strongly forced towards the cavity of the knuckle-bone and so at length restored. (Fig. 1.)

" When the head of the thigh by just extension is freed from the muscles wherewith it was infolded, and the muscles also extended that they may give way and yield themselves more pliant then must the rope be somewhat slacked otherwise the restitution cannot be performed for that the stronger extension of the engine will resist the hand of the surgeon, thrusting and forcing it into the cavity. You shall know that the thigh is restored by the equality of the legs, by the free and painless extension and inflection of the lame leg. Then must both the thighs be bound together whereby the dislocated member may be unmoveable and more and more strengthened. To conclude the patient must be kept in his bed for the space of one month, that the relaxed muscles, nerves and ligaments may have space to recover their former strength, otherwise there is danger lest the bone may again fall out by the too forward and speedy walking upon it.

FIG. 1

Reduction of an " inward " dislocation of the hip. The perineal post is not shown. Note that the traction rope is fastened above the knee, not below as is done by *clownish and ignorant knot-knitters*. (From the English translation [1678] of Paré's work.)

OF RESTORING THE THIGH DISLOCATED OUTWARDLY

" The patient must be placed grovelling upon a table in this kind of dislocation also, and ligatures as before cast upon the hip and lower part of the thigh, then extension must be made downwards and counter-extension upwards then presently the head of the bone must be forced by the hand of the surgeon into its place. If the hand be not sufficient for this purpose our pulley must be used.

" This kind of dislocation is the easiest restored of all those which happen in the thigh or hip for that I have divers times observed the head of the thigh to have been drawn back into its cavity somewhiles with a noise or pop, otherwise without."

Other Renaissance authors have nothing valuable to add to Paré's recommendations. The scamnum, that most versatile and ancient appliance, was used by Vidius for a dislocated hip as for so many other injuries. Indeed, until the days of Bigelow, increasingly powerful traction-devices giving more and more pull were the only additions to the surgeon's stock-in-trade for this dislocation as for all others. Three simple methods from Galen are worth noting: straddling the patient across a bar and tying a large full earthenware jug to

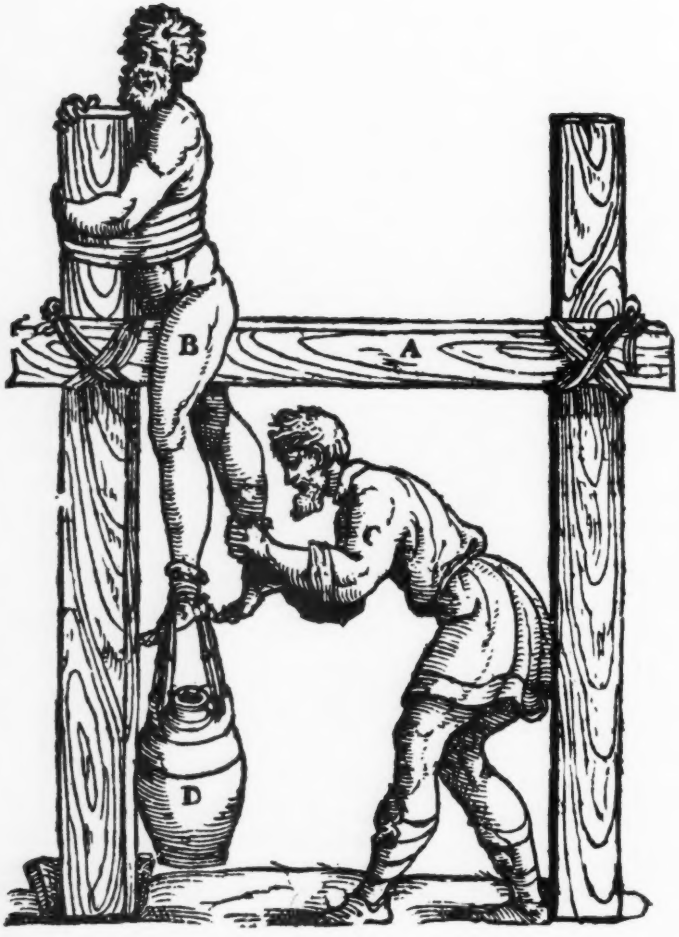

FIG. 2
Reduction over a beam. (From the *Opera* of Galen, 1625.)

FIG. 3

Reduction by ladder and weight-on-ankle. (From the *Opera* of Galen, Venice edition, 1625.)

FIG. 4

Pugh's traction with a vengeance! A third technique from Galen (*loc. cit.*).

the affected leg (Fig. 2); a ladder and weight round the ankle (Fig. 3); and even hanging him upside down by his heels and swinging upon him (Fig. 4) as was the habit of the hangman when traction had to be increased in the other direction.

It is well to remember that we are not far from those days. Even the text-books of to-day contain references to the block-and-tackle in reducing dislocations of the hip, and Treves's (1923) vivid account of such an operation describes a standard method of only seventy years ago. It was his first visit to an operating theatre, where he laid hold of a rope upon which two men were already pulling. He " was afterwards informed that the operation in progress was the reduction of a dislocated hip by compound pulleys. The hip, however, was not reduced." He adds, with an amusing overstatement, that in 1923 " a well-instructed schoolgirl could reduce a recent hip dislocation unaided." It is as well for us to remember that such truth as that statement contains reflects credit rather upon our anaesthetists than upon any orthopaedic surgeon of any century.

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PROCEEDINGS AND REPORTS OF UNIVERSITIES, COLLEGES, COUNCILS AND ASSOCIATIONS

GREAT BRITAIN

ROYAL COLLEGE OF SURGEONS OF ENGLAND

THE QUEEN'S HONORARY FELLOWSHIP

At a ceremony on March 20, 1950, the Queen was admitted to the honorary Fellowship of the Royal College of Surgeons of England. In welcoming Her Majesty, the President, Sir Cecil Wakeley, spoke of the warmth of interest shown by the Royal Family in the profession of surgery. He spoke of the many evidences of royal encouragement, from King Henry VII's grant of arms to the Surgeons Company in 1492 to King George IV's gift of the mace now lying on the table. Then, in the present century, King Edward VII, King George V and the Duke of Windsor had each while Prince of Wales accepted the honorary Fellowship of the College; Queen Mary had twice visited the College to encourage their efforts in making good the damage of war. In 1937 King George VI assumed the post of Visitor and a few years later witnessed the admission of the Duke of Gloucester to an honorary Fellowship. "To-day," the President said, "we could not have hoped for an occasion of greater distinction as the first and foremost event in the celebration of the one hundred and fiftieth anniversary of the granting of the first Royal Charter to the College."

The Vice-Presidents, Sir Harry Platt and Mr Ernest Finch, next stepped forward to present the Queen. Sir Harry Platt said that Fellows and Members of the College throughout the Commonwealth and Empire were ever mindful of the Queen's deep and sympathetic interest in the relief of suffering. Her visit to the College would be held as an honour conferred on all those who, armed with the College's Fellowship, had gone forth to practise the healing art of surgery.

The President, addressing the Queen, then said: "In the name of the Royal College of Surgeons of England and by the authority of the Council, I hereby admit you a Fellow thereof, *honoris causa*."

The Queen was warmly cheered by the Fellows and Members attending. Her Majesty said: "As we stand here to-day and turn our gaze back down the long passage of time, we cannot refrain from giving thanks for the progress of surgery in all its branches. It is not necessary to go back the full span of one hundred and fifty years since the College received its first Royal Charter to find conditions so primitive that one hesitates to recall them. Now all that is past; and I feel that the Royal College of Surgeons must rejoice with great pride at the part which its Fellows and Members have played in bringing the standard of surgery in our country to its present pre-eminent position.

"To-day, the skill and wisdom of our surgeons is available, in full measure, for all our people, and there must be many families in the land which have cause to be grateful—as indeed has my own.

"I am glad to think that the future is as rich in promise as the past has been in achievement. The Restoration and Development Fund, together with Lord Nuffield's wonderful gift for the Nuffield College of Surgical Sciences, will provide the new buildings so essential to the continued extension of research and to the ever wider dissemination of knowledge, and, in addition, will enable the teaching to be carried on in an atmosphere of collegiate life. In particular, the courses held for post-graduate students are of widespread benefit.

"Therefore I feel that I can congratulate the College with confidence because the traditions on which its great reputation rests are stronger and more precious than ever, and have, moreover, become a part of our national life. You will, therefore, perhaps allow me to give a message of greetings on this occasion to all the Fellows and Members of the College, wherever they may be, all over the world.

"Surgery is a vocation which demands and secures from those who respond to it a constancy of Christian charity and understanding which elevates it above merely professional levels. The people of this country know that these standards are upheld and they would, I am sure, join with me in expressing to you all these words of appreciation. May God's blessing continue to rest upon your work."

HUNTERIAN LECTURES

Lumbar intervertebral disc protrusion—In a Hunterian lecture delivered at the Royal College of Surgeons on February 16, 1950, *Professor J. E. A. O'Connell* reviewed 500 surgically treated cases of lumbar intervertebral disc protrusion, with special reference to the late results of operation. There were 330 male and 170 female cases; almost three-quarters (72 per cent.) of all the patients were between twenty-one and forty years old.

Clinically, signs were divided into three groups: 1) *Spinal signs*—there was reduced mobility in all cases; reduction of the normal lumbar curve in 82 per cent.; and scoliosis in 48 per cent. 2) *Tension signs*—the straight leg raising test was positive in greater or less degree in 99 per cent.; in all the 1 per cent. showing a negative result the prolapse was in the upper lumbar region. The femoral nerve stretch test was useful for upper lumbar disc protrusions. 3) *Neurological signs*—some motor weakness was observed in 96 per cent. of the cases and some sensory impairment in 80 per cent. The distribution of the leg pain was important in localising the level of the protrusion. Radiation to the heel, sole and outer margin of the foot indicated protrusion of the L.5–S.1 disc; to the dorsum of the foot and hallux, the L.4–5 disc; and the anterior aspect of the thigh down to the patella, the L.2–3 or L.3–4 disc. Lumbar puncture showed increased protein in thirty-one of forty-one cases examined. *Operation* was undertaken in only 15 per cent. of the cases seen in the out-patient department. The aims of the operation were: first, to remove protruded disc material; second, to remove osteophytic vertebral margins; third, to clear adhesions round the root; and fourth, to remove as much disc material as possible. Adequate exposure was obtained by removing the lower margin of the lamina appropriate to the side and indicated level of the lesion, together with the ligamentum flavum below. The spinous processes were not removed. The adjacent disc was exposed by a similar approach in 21 per cent. of cases. Patients got up on the eighth day and began spinal exercises on the tenth day.

The protrusion was at the L.5–S.1 level in 49·6 per cent. of the cases; at the L.4–5 level in 39·6 per cent.; combined L.4–5 and L.5–S.1 in 9·2 per cent.; and L.2–3 or L.3–4 in 1·6 per cent. Lesions were of three types: 1) a protrusion without ligamentous covering (12·5 per cent.); 2) a large protrusion with a thin ligamentous covering (64·7 per cent.); and 3) a small protrusion, recognised by abnormality of the posterior common ligament (22·8 per cent.). No disc protrusion was found in eighteen out of 518 explorations. Results were assessed on the basis of symptoms, working capacity, physical signs and recurrences. There was complete relief from symptoms in 60·7 per cent.; great improvement (occasional backache after heavy work) in 31·6 per cent.; and improvement (persistent pain, but less than before operation) in 4·7 per cent. Unchanged, 3 per cent. Working capacity: 92·8 per cent. returned to full work; 6·5 per cent. had reduced capacity; 0·7 per cent. were unable to work. Spinal signs and tension signs were absent or markedly reduced in 80 per cent. of cases. Motor disturbance persisted in 15 per cent., sensory disturbance in 30 per cent. and reflex disturbance in 62 per cent. Ten patients had recurrences of sufficient severity to warrant further operation.

Fractures of the radius and ulna—*Professor E. M. Evans*, in his Hunterian lecture delivered on February 28, 1950, emphasized the importance of diagnosing and correcting rotational deformity if subsequent loss of forearm rotation were to be avoided. Discrepancy of the apparent width of the fragments of the radial shaft, at the level of fracture as seen in the radiographs, indicated rotational deformity. The degree of rotation of the proximal fragment of the radius should be determined by comparison of the radiographic appearance of the bicipital tuberosity and the neck of the radius with that of the tuberosity in the uninjured arm; routine radiographs should be taken in at least three positions, namely mid-rotation, and 120 degrees and 150 degrees of supination. The proximal fragment of the radius would remain in each individual case in a constant position of equilibrium determined by the soft tissues; at manipulation, the distal fragment should be rotated into the position indicated by the comparison of the tuberosity views; rotational displacement would then be corrected. Though the comparison of the radiographs was not easy in children, it could nevertheless be accurate and the routine should be followed. Hitherto accepted teaching of the relation of degree of rotation of the proximal fragment to the level of fracture was unreliable. Manipulative reduction should always be attempted for closed fractures of both forearm bones. He had obtained acceptable primary manipulative reduction in 76 per cent. of cases. When it was felt that the reduction might not be stable, thumb traction should be used for two weeks. Open reduction with plate fixation was recommended as a primary procedure for oblique fractures of the lower shaft of the radius with inferior radio-ulnar dislocation. There was potential instability in fracture of the lower radial shaft without apparent subluxation of the inferior radio-ulnar joint and fracture of the lower radial shaft with an oblique fracture low down in the ulna; such fractures should be treated by thumb traction for the first two to three weeks in plaster. If displacement occurred they should be plated.

Fractures of the lower radial shaft might occasionally be associated with dislocation of the superior radio-ulnar joint; the radius should be plated and the forearm immobilised in full supination.

The indications for open reduction and internal fixation were summarised as follows:

As a primary procedure: 1) in oblique fractures of the shaft of the radius with radio-ulnar dislocation; 2) in compound fractures when a skin flap was necessary.

As a delayed procedure: 3) when fractures displaced after reduction and immobilisation, despite thumb traction; 4) in cases of delayed or non-union; 5) when manipulative reduction was necessarily delayed by reason of other injuries.

Plate fixation as a routine procedure was not advised. The results of fifty cases of closed complete fractures of both forearm bones treated conservatively by manipulation under general anaesthesia with X-ray control and plaster were presented. Union occurred in all cases, the average time being fourteen weeks in patients over sixteen years and seven weeks in those under sixteen. Eighty-two per cent. remained in position in plaster, 14 per cent. shifted slightly, 2 per cent. malunited, 2 per cent. collapsed in plaster; only in one case did rotational deformity exceed 30 degrees; normal or near normal function was obtained in 90 per cent. of cases and there were no other complications.

BRITISH ORTHOPAEDIC ASSOCIATION

SPRING MEETING, 1950

The Spring meeting of the British Orthopaedic Association was held in Cardiff on April 21 and 22, under the presidency of *Mr S. L. Higgs*. Papers were presented in the Reardon-Smith Lecture Theatre of the National Museum of Wales, and clinical cases were shown at the Cardiff Royal Infirmary.

The end-results of fracture of the patella—*Mr J. Todd* (Newcastle) reviewed the results of forty-six cases of fracture of the patella, sixteen cases treated by suture with catgut and thirty cases by excision of the patella. Fractures treated by suture were, with three exceptions, of the transverse type; those treated by excision included both transverse and comminuted fractures. After suture, the knee had been immobilised in plaster for six weeks. Movement had increased for up to nine months. After excision, immobilisation had been maintained for three to four weeks; movement was usually regained more rapidly than after suture. Good or excellent results—assessed on power, movement and capacity for work—were gained in 68 per cent. of the cases treated by suture and in 80 per cent. in those treated by excision. In general, movement was slightly better after excision, but power was better after suture. *Mr K. H. Pridie* (Bristol) advocated repair of transverse fractures by a single vertical screw, which afforded better apposition and fixation than suture with catgut and allowed immediate movement to be begun. *Mr F. G. Badger* (Birmingham) considered that extension lag was liable to develop if the plaster was removed early after excision: he advised immobilisation for six weeks. Suture was undertaken only in the younger patients. Excision of the smaller fragment only was capable of giving results equal to the best results of suture and had a place in the treatment of selected cases. *Mr E. N. Wardle* (Liverpool) believed that extension lag after excision could be prevented by care in the post-operative treatment. Flexion movements should not be begun until the power of active straight leg raising had been regained.

The manubrio-sternal joint in ankylosing spondylitis—*Mr D. L. Savill* (Edinburgh) had studied the condition of the manubrio-sternal synchondrosis in sixty-one cases of ankylosing spondylitis, and had found evidence of pathological changes in 72 per cent. Radiographically the joint was shown best by a lateral projection. The bony margins of a normal joint were smooth, slightly convex, and separated by a clear cartilage space. When the joint was affected in ankylosing spondylitis there was progressive narrowing of the cartilage and erosion of the bone ends. The process was limited by a narrow zone of sclerosis, and the joint line was increased in depth antero-posteriorly. In the later stages the joint was obliterated completely by bony ankylosis. These changes were essentially similar to those occurring in the sacro-iliac joints. In twenty-two patients with rheumatoid arthritis the manubrio-sternal joint was normal radiographically in thirteen, slightly narrowed in four, and partly or completely fused in five: erosion of the bone ends was not observed. Histological examination of the joint surfaces in ankylosing spondylitis showed that in the areas of erosion bone was replaced by collagenous fibrous tissue, without inflammatory reaction. These changes were absent in rheumatoid arthritis.

The hip in fibrous dysplasia—*Mr A. C. Bingold* (Leeds) showed radiographs of five patients whose bones in the region of the hip joint were affected by fibrous dysplasia of the monostotic or polyostotic type. He recalled that the characteristic radiographic appearances consisted of "ground glass" cysts with expansion of the cortex and scattered dark shadows. Histological examination showed trabeculae of immature bone scattered among cellular fibrous tissue. Giant cells were not observed. *Professor Sir H. Platt* (Manchester) criticised the use of the term "dysplasia" for conditions that developed in bones previously normal: the term should be applied only to lesions present from birth. The cases illustrated were examples of dystrophic lesions. Histopathological study of bone, except in tumours, was disappointing and seldom informative.

Pseudarthrosis of the tibia—*Mr Bryan McFarland* (Liverpool) discussed the results in nine cases of pseudarthrosis of the tibia which had been treated by the "by-pass" bone-grafting operation described

by himself in 1940.* He recalled the essential features of the operation, which consisted in placing a cortical graft as a strut to bridge the pseudarthrosis (without correction of the anterior angulation), the ends of the graft being locked into notches cut in the upper and lower fragments. The strut resisted the bending stresses acting at the site of fracture. The operation had been successful in securing bony union in seven patients, and unsuccessful in two. The failures were probably to be explained by technical errors: in one case the lower end of the graft was notched into the tibia too close to the fracture, and in the other the operation was undertaken too soon. The marked tendency for pseudarthrosis to persist in spite of the usual forms of conservative and operative treatment was due entirely to mechanical factors: immobilisation was not sufficiently complete to overcome the bending stresses that were so inimical to the formation of lamellar bone. Pseudarthrosis of the tibia was neither a birth fracture nor a non-fusion of two separate centres of ossification. It was a stress fracture in a congenitally abnormal tibia. The abnormality occurred in the mesenchyme; it might give rise to a cyst or to an area of slender bone of inadequate strength. Pseudarthrosis had been produced experimentally in chickens by injecting insulin into the embryo at the appropriate period of development.

Walking aid for use in spastic paraplegia—*Mr John Charnley* (Manchester) demonstrated an ingenious walking aid used by a young patient with spastic paraplegia. The device, which had been designed by the patient's father, consisted essentially of two pairs of walking sticks, the members of each pair being hinged near their upper ends and joined by a cross-bar to the other pair, after the manner of a folding trestle. It was fitted with bicycle hand-grips. Progression was made by advancing alternately the front and rear pairs of legs. A notable feature of this walking aid was its complete rigidity while at rest.

V-Arthrodesis of the hip—*Mr R. C. Howard* (Norwich) described a method of arthrodesis of the hip (developed in association with Mr H. A. Brittain) in which fixation of the joint by a nail was combined with ischio-femoral grafting. The bed for the graft was prepared by passing a wide drill through the upper part of the femoral shaft into the ischium. The nail and the graft formed a **V**, which made for mechanical rigidity. Prolonged immobilisation in plaster was unnecessary, and walking with crutches could be allowed within a few weeks of operation. The main indication for the operation was unilateral osteoarthritis of the hip. Sound bony fusion had been achieved in fourteen of seventeen patients operated upon.

Oblique osteotomy for osteoarthritis of the hip—*Mr G. V. Osborne* (Liverpool) reviewed seventy-five patients in whom oblique displacement osteotomy of the femur had been undertaken for osteoarthritis of the hip.†

Pseudarthrosis of the hip joint—*Mr R. G. Taylor* (Oxford) reported the late results in ninety-three patients treated for osteoarthritis of the hip, ankylosing spondylitis and other conditions, by excision of the head and neck of the femur.†

Discussing the three preceding papers, *Mr H. A. Brittain* (Norwich) conceded that the best results of arthroplasty were better than those of arthrodesis. But the results of arthroplasty were often bad. Arthrodesis was more reliable. *Mr W. A. Law* (London) believed that there was not, and never would be, a universal operation for osteoarthritis of the hip. The treatment of every case must be decided on its merits. *Mr O. Vaughan-Jackson* (London) said that any method of arthrodesis in which external fixation was omitted would stand by the efficiency, for an adequate term, of the internal fixation. The efficiency of nail fixation was greatest when the nail penetrated the femoral neck eccentrically and therefore away from its centre of rotation. *Mr Norman Capener* (Exeter) emphasized the merits of the posterior approach to the hip joint. He could not agree with those who stated that cup arthroplasty was a more formidable operation than pseudarthrosis. *Mr K. H. Pridie* (Bristol) believed that excision of the head and neck of the femur was superior to cup arthroplasty for ankylosing spondylitis. In treating osteoarthritis there was a place for osteotomy, particularly if prolonged immobilisation in plaster was avoided by plate fixation.

The treatment of established Volkmann's contracture by tendon transplantation—*Mr A. R. Parkes* (Glasgow) had treated two patients with established Volkmann's contracture by tendon transplantation designed to restore independent action to the flexor digitorum profundus tendons without interfering with active movement at the wrist. He recalled that by the use of flexion-extension movements of the wrist many patients were able to move the fingers through a limited range despite the loss of independent action of the finger flexors. It was unwise to sacrifice these " trick " movements by arthrodesis of the wrist, which had sometimes been advised in conjunction with tendon transplantation. The operation he had used consisted in division of the contracted finger flexors (sublimis and profundus), division of contracted wrist flexors, and transfer of extensor carpi radialis longus to the distal stumps of the profundus tendons above the transverse carpal ligament. The operation had given promising results. *Mr D. Ll. Griffiths* (Manchester) recalled that the extensor muscles were often affected in Volkmann's ischaemia. It was necessary to be quite certain that there was adequate voluntary power in the wrist dorsiflexors before undertaking this operation. *Mr H. J. Seddon* (London) hoped that the operation might reduce the indications for prolonged

* McFarland, B. L. (1940): British Journal of Surgery, **27**, 706.

† Paper published in full in this issue of The Journal of Bone and Joint Surgery.

stretching of the contracted tissues and for such operations as shortening of the forearm bones. The muscles affected most seriously by ischaemia were the flexor digitorum profundus and flexor pollicis longus. Involvement of the superficial flexors was often relatively slight, and their action could be adequately reinforced by transplants. Arthrodesis of the wrist made available sufficient extensor tendons for transfer to flexor pollicis longus as well as to the finger flexors.

Osteochondromatosis of the hip joint—*Mr Ross Bloom* (London) reported three cases of osteochondromatosis of the hip joint. In a study of the literature he had found reference to twenty-one cases of the condition affecting the hip joint out of a total of 184 cases. He considered that areas of erosion at the cervico-capital junction, usually observed in plain radiographs, were caused by pressure absorption. The defects tended to become filled in by deposition of new bone after removal of the loose bodies. Arthrography after injection of 35 per cent. diodone was of value in diagnosis.

An experimental study of tendon growth in the rabbit—*Dr G. N. C. Crawford* (Oxford) had placed multiple indian ink marks along the length of suitable tendons of growing rabbits and had measured the intervals between the marks. The same intervals were measured again after killing the rabbits three to four months later. Growth of tendon occurred interstitially throughout its length. The most rapid growth was near the muscle-tendon junction.*

Amputations of lower limb for vascular disease—*Mr Harman Smith* (London) had examined 138 amputation stumps in ninety-five patients with primary vascular disease of the lower limbs. The object of his investigations had been to assess the criteria for determining whether below-knee amputation was likely to be adequate. Of eighty-one below-knee stumps, twenty-seven had proved satisfactory and fifty-four unsatisfactory. The most significant factors were age, the state of the popliteal pulse and the amount of bleeding at operation. In every case in which below-knee amputation was adequate the patient was younger than fifty-two years at the time of operation. Absence of the popliteal pulse did not always indicate that below-knee amputation would be inadequate: in thirteen patients in whom the popliteal pulse was not palpable before operation, a below-knee stump proved satisfactory. The most valuable criterion was the amount of bleeding at operation and the appearance of the muscles. When bleeding was sluggish and the muscles grey, amputation at a higher level was indicated; but where free bleeding occurred from healthy muscles, a satisfactory stump could be expected. Used with other tests of circulatory function (skin temperature tests, tourniquet tests and oscillometry), these criteria were reasonably reliable in indicating the lowest practicable level for amputation. Stumps that were unsatisfactory usually broke down within six months of amputation. *Mr L. Gillis* (London) emphasized the importance of preserving a below-knee stump whenever possible. *Mr St J. D. Buxton* (London) regretted that many surgeons who amputated limbs for primary vascular disease failed to observe the late condition of the stump. Not uncommonly the activity of the disease subsided and the circulation might improve.

Histology of bony union—*Mr John Charnley* (Manchester) showed histological sections taken from the line of arthrodesis at various intervals after " compression " arthrodesis of the knee. He demonstrated convincingly that the line of fusion was bridged by trabeculae of woven bone as early as four weeks after operation. At eight weeks healing by fully established woven bone was almost mature. It was still uncertain whether this rapid bony union was determined by pressure or simply by close apposition of the fragments. *Professor J. Trueta* (Oxford) suggested that close contact of the fragments minimised the need for new vessel formation. Union was rapid because healthy cells were in close apposition, and the development of a preliminary vascular network to bridge the gap was unnecessary.

Monteggia fracture with posterior dislocation of radial head—*Mr J. H. Penrose* (Bristol) reported seven cases of Monteggia fracture with posterior dislocation of the radial head. He considered that the mechanism of the injury was similar to that which caused posterior dislocation of the elbow—a fall on to the hand, the elbow being slightly flexed and the forearm in moderate pronation. In every case there was a marginal fracture of the head of the radius. Treatment was by intramedullary fixation of the ulna, and excision of the radial head or of the detached fragment. All patients regained good function but some limitation of elbow movements was usual. *Mr E. Mervyn Evans* (Birmingham) agreed that the injury was closely related to posterior dislocation of the elbow. He thought that closed manipulation—by full extension and supination—should be tried before open operation.

The movements of the tarsus—*Mr E. Shephard* (London) had observed the movements of the tarsal joints in living and in dead feet. Only two movements were possible: supination (combined inversion and adduction) and pronation (combined eversion and abduction). These movements might take place at the peritalar joint or at the midtarsal joint. The peritalar joint comprised the talo-navicular joint and the subtalar joint; its mechanism was comparable to that of the radio-ulnar joints. The peritalar joint allowed a wide range of supination and pronation about an axis directed obliquely downwards and backwards through the body of the talus. The midtarsal joint allowed a small range of supination and pronation about a similar axis.

* Paper published in full in this issue of The Journal of Bone and Joint Surgery.

Fracture of the lateral malleolus—*Mr David Thomas* (Scunthorpe) presented an analysis of 109 stable fractures of the lateral malleolus, fifty-nine treated by immobilisation in plaster and fifty by simple strapping. The average period of incapacity was eleven and a half weeks for patients treated in plaster, but only six weeks for patients treated by strapping. The incapacity period was not closely related either to age or to the type of fracture. The slower rate of recovery with the plaster method was probably due to loss of the normal pump action of the muscles (and consequent oedema) while in plaster, and to interruption of the normal walking habit: the patient had to recover from the immobilisation as well as from the fracture. Fractures of this type should be treated by strapping. *Mr H. Osmond-Clarke* (London) said that if these fractures were to be treated by strapping it was necessary to be quite sure that the fracture was stable. *Mr V. H. Ellis* (London) doubted whether working time was saved by avoiding plaster. Many patients were able to return to work in plaster who otherwise would be unwilling to do so because of pain. *Mr P. H. Wiles* (London) and *Mr W. D. Coltart* (London) favoured plaster immobilisation.

THE ROBERT JONES GOLD MEDAL AND PRIZE

The award for 1949 has been made to Mr E. Mervyn Evans for his essay, "Pronation and Supination: the Importance of the Rotation Element in the Treatment of Injuries of the Forearm."

ROBERT JONES GOLF CUP

After eighteen holes of medal play over the Royal Porthcawl Course, G. K. McKee (82 − 14 = 68) won the Cup for 1950. G. R. Girdlestone (86 − 9 = 77) was second and John Todd (78, scratch) was third. There were fifteen entrants.

The Porthcawl Course, on the north shore of the Bristol Channel, is one of the best in Wales. On that sunny spring day it was in beautiful condition, and those out early had the added interest of watching a school of porpoises chasing salmon close inshore.

Play for the Robert Jones Golf Cup is held annually just before the Spring Meeting of the British Orthopaedic Association. The cup, commemorating a great surgeon who had also a fine enthusiasm for sport, was presented to the Association by the late Rowley Bristow, who followed his chief in both these interests.

UNIVERSITY OF LIVERPOOL

MEMORIAL TO THE LATE PROFESSOR T. P. McMURRAY

It has been suggested that a fund should be created to give enduring recognition to the services of the late Professor T. P. McMurray who, by his skill as surgeon and as teacher, has enhanced a great tradition. With the object of perpetuating his memory it is proposed to raise a Memorial Fund, to be offered to the University of Liverpool for the establishment of a Prize for clinical work in Orthopaedic Surgery to be associated with the name of T. P. McMurray.

Contributions should be sent to Mr Bryan McFarland, Department of Orthopaedic Surgery, The University, Liverpool, 3.

ROBERT JONES NATIONAL MEMORIAL FUND

Travelling Research Fellowship—The first award under the terms of the Fund will be made jointly by the University of Liverpool and the Liverpool Medical Institution. Candidates have been invited to outline their proposed course of study or programme of research and to name the Orthopaedic Centre they would visit. A sum of five hundred pounds will be made available to the first Fellow elected; he will hold the title for one year and will be required to travel abroad for a substantial part of the time. During the remainder of the year he will be free to accept other appointments but will be required to submit a report on his foreign travel and research to the nominating body at the end of his tenure. Further details may be had on application to the Dean of the Faculty of Medicine, The University, Liverpool, 3.

LIVERPOOL MEDICAL INSTITUTUON

Insulin-induced skeletal abnormalities in developing chickens—At an Ordinary Meeting held at the Liverpool Medical Institution on Thursday, January 19, 1950, with the president, Professor Charles Wells, in the chair, *Mr P. K. Duraiswami* read a short paper on "Insulin-induced Skeletal Abnormalities in Developing Chickens." Mr Duraiswami said that in recent years it had been repeatedly shown that congenital malformations which were sometimes genetically determined could also be produced in the offspring by maternal nutritional deficiencies. For instance, maternal vitamin-inadequacy, contraction of rubella by

the mother early in pregnancy, and Roentgen irradiation might each result in a defective offspring; so might certain substances like insulin if introduced into the environment of the developing embryo. Skeletal abnormalities like spina bifida, partial or complete suppression of vertebrae, deformities of the feet, congenital dislocation of the hip, arthrogryposis and osteogenesis imperfecta have been experimentally induced in developing chick embryos by injecting suitable doses of insulin into eggs. The technique of injection into the yolk was described, the relationship between the time of injection of insulin and the type of deformity were discussed, and the defects were illustrated in detail by slides and cinematograph films.

The intervertebral disc—A discussion was opened with a paper, " Experimental Investigations into the Physical Properties of the Intervertebral Disc," by *Mr W. J. Virgin* (read on the author's behalf by Mr G. V. Osborne). *Mr E. N. Wardle* spoke on " Conservative Treatment of the Disc Lesion." In suggesting that a disc lesion involved the whole lumbar spine he emphasized that spinal deformity was the one thing which distinguished the condition from the many causes of similar pain. The usual history of intermittent backache, culminating in acute sciatic radiation; the association of muscle spasm with the characteristic spinal list; and the strongly positive leg raising test all confirm this point. Loss of normal elasticity, resulting in instability of the lumbar spine, was discussed in its relationship to backache, bulging of the disc and final displacement of the disc with incidental sciatic signs and symptoms. The so-called conservative treatment was shown to be based on the accepted principle of correction of a deformity and retention of the corrected position. Of the several methods a strong preference was expressed for the head-suspension plaster followed by a support. This was shown to have produced successful results in 70 per cent. out of 269 cases. It was claimed that this method not only relieved the symptoms but also established again the integrity and function of the spinal column. The 30 per cent. represented those cases in which there was no power to regain elasticity and it was felt that this was the true indication for removal of the disc.

Mr A. Sutcliffe Kerr spoke on the " Operative Treatment of the Disc Lesion," and said that operative treatment for ruptured intervertebral discs should only be considered when conservative treatment had failed. He believed three weeks' absolute bed rest to be an adequate form of conservative treatment, and to rest the intervertebral disc at least as well as when the patient was ambulant in plaster. Neurological signs were usually present, the most constant being limitation of straight leg raising and diminution of the ankle jerk. Radiography he considered not of much help; myelography should only be employed for cases where the history is not characteristic and there is a suspicion of other disease, such as cauda equina tumour. The operation of choice is a fenestration operation with a minimal removal of bone; in difficult cases a hemi-laminectomy gives an adequate exposure. Fusion of the spine is not recommended simultaneously with disc removal, but may occasionally be necessary if there is subsequent severe back pain. Statistics from recent literature, and from his own cases, were quoted. These showed that between 50 and 60 per cent. of cases of sciatica were cured by removal of the protruded disc, and a further 25 to 30 per cent. substantially improved. Between 10 and 15 per cent. were not relieved, but only about 1 per cent. made worse.

Bone-grafting—At an Ordinary Meeting of the Liverpool Medical Institution held on March 30, 1950, with *Mr H. V. Forster*, vice-president, in the chair, *Mr Bryan McFarland* read a paper on "Bone-grafting." After classifying the various types of bone-graft according to source, shape and purpose, and then discussing the fate and function of a graft, Mr McFarland described the technique he had used with reasonable success for just over twenty years. Out of 105 cases of all kinds primary union had occurred in ninety-eight cases, and in five of the remaining cases union had been obtained at the second attempt. The graft was part cortical and part cancellous, used as a semi-onlay and fixed on the " door-bolt " principle. He deprecated the use of metallic fixation, advocated taking grafts with a chisel and stressed the importance of proper preparation of the bed. Most of the illustrations were of grafts placed across large gaps in bone.

In the discussion which followed, *Mr Goronwy E. Thomas* said that we still knew little about the way in which bone grafts function, and it was therefore impossible to lay down rigid rules about bone grafting. All orthopaedic surgeons were probably familiar with cases where the ideal type of grafting had been performed—the graft accurately inserted and firmly embedded in the recipient bone—yet union failed. On the other hand, they were equally familiar with cases where an indifferent sort of grafting operation had been carried out, without fixation of the graft, but union occurred readily. However, one thing was certain—that the graft must make contact with healthy bone on each side of the fracture, and that this contact must be maintained during the initial stages of repair.

Mr Horace Davies asked if Mr McFarland had any knowledge of the grafting of pathological bone into normal. The speaker was particularly interested in osteitis deformans and recalled that when Sir James Paget first described the condition he suggested it was of a chronic inflammatory nature. Although many other theories about its etiology had since been suggested, no definite evidence had been brought to contradict this original theory. It occurred to Mr Davies that experimental research into the subject of the transplantation of Paget's bone into normal might open up a new line of inquiry by the study of the reaction within the normal tissues.

Mr R. P. Osborne said that the latch graft was a very fascinating idea, but, whilst it might be used

by the plastic surgeon for his grafts to fingers, there seemed little indication for it in grafts to the mandible since so often one of the bone ends was extremely thin in this site. Mr Osborne was anxious to know whether bone grafts inserted during childhood grew as the child increased in size. He believed they did not, and that the failure to grow was a hindrance in treating cases of agenesis of the ascending ramus of the mandible. The use of homogeneous bone grafts, although an accepted practice, should never be allowed unless a Wassermann reaction had been obtained from the donor: unfortunate results had followed the omission of this procedure. Stored bone had not been used by Mr Osborne, but preserved bovine cartilage had proved of great value.

ROYAL SOCIETY OF MEDICINE

SECTION OF ORTHOPAEDICS

President's Address—Mr Norman Capener delivered his presidential address, on " The Hand in Surgery" at a meeting of the Section of Orthopaedics on March 7, 1950. His purpose was to show surgeons how a study of the manner in which their instruments were used in their own hands could increase their knowledge of the hand itself. They would also appreciate more closely the effect of injury upon function in other craftsmen. He disagreed with the common use of the term " position of function " for partial dorsiflexion and radial deviation, and pointed out how often the hand was used in palmarflexion or in ulnar deviation. He showed that, when an instrument or tool—for instance, a mallet—was used from the radial side of the hand, the lateral movement of the wrist joint was geared up, that is to say there was more movement but less precise control; the converse held for a tool such as a chisel, which is used from the ulnar side, and there is more precise control with less range of movement. He described flexor carpi ulnaris as the tendo Achillis of the hand—the pisiform being so situated that it moves in a circle around the axis of lateral movement of the wrist joint.

He condemned arthrodesis of the wrist as a crippling operation; speaking of its use for ununited fractures of the scaphoid, he pointed out that that bone does not permanently enter into the radio-carpal joint because the hand is so often used in ulnar deviation. Another anatomical point, ingeniously illustrated with a model, was that pronation-supination movement is not solely of the radius around the ulna, but that the latter bone also moves; the axis of longitudinal rotation of the forearm is in the centre of the radius.

Regarding the relative importance of the right and left hands, he thought of the right hand (in a right-handed person) as more " conscious " than the left, and as concerned with " dynamic function," whilst the left hand mainly controls static function.

He advocated the design of surgical instruments and splints to fit the true physiological positions of the hand, remembering particularly the obliquity of the metacarpals and of the palm in the lateral plane. Springs for use with splints for paralysed muscles should not be stronger than power 4 of the Medical Research Council classification. It must have surprised many surgeons present to learn that the mechanics of coiled springs are such that their power is greater the smaller the diameter and the fewer the number of coils. This was strikingly illustrated by a model.

Mr Capener ended his address by saying that surgeons were fortunate that their work combined intellectual function with craftsmanship. The mechanism of the hand in general life was well revealed in the craft element in surgery itself.

A collection of beautifully designed and beautifully made splints for the hand was shown by the president after his address. Some retractors, with specially designed handles to fit the hand and so avoid fatigue, were also inspected with great interest.

INSTITUTE OF ORTHOPAEDICS

CONVERSAZIONE IN THE NEW PREMISES

On April 27 the Institute of Orthopaedics held a Conversazione—a housewarming of the first section of their town premises at the old hospital in Great Portland Street. Other developments have been begun at the country section, Stanmore; when these are complete, still further expansion will be made in London. The guests of the evening included a great many who have been concerned since the war in developing medical postgraduate facilities of a university standard in London. Mr H. J. Seddon, the Director of Studies, welcomed the guests. He reminded them that the Institute was a child of the British Postgraduate Medical Federation of the University of London and owed a particular filial duty to the Director of the Federation, Professor Sir Francis Fraser, whose help (with the co-operation of the Hospital) had been invaluable. After refreshments, the premises and exhibits by the staff were opened to view.

The premises, converted from disused wards when building was impossible, include pathological laboratories containing many ingenuities, an exceedingly well-equipped photographic department, a small library which has been enriched by many gifts from older bodies, a modern records department and a lecture and demonstration room which is in many ways unique and a model for the future. Exhibits of some of the present activities of the Institute were shown. They included work on neuro-muscular and

vascular physiology, the organic constituents of bone, a serological test for staphylococcal osteomyelitis, fat embolism, the ill-effects of general rest and methods of avoiding them, radiological investigation of joints, the epidemiology of poliomyelitis in closed communities, investigation of plastic materials over a remarkably wide field and finally the work of some of the special clinics—scoliosis, limb equalisation, congenital dislocation of the hip, etc. Besides these and other current activities, photographs and radiographs were shown from the very large collection of the Institute and Hospital. In the library the post-war publications of the staff were ranged beside an interesting exhibit of books and portraits, some on loan from the Royal Society of Medicine, illustrating the development of orthopaedics from early times.

Perhaps the most striking impressions of the evening were the intense activity of the Institute during the short period of its existence—less than four years—and the cunning exploitation of every inch of limited and unpromising space.

VISIT OF JUNIOR SURGEONS FROM THE CONTINENT

The success of last year's week for junior orthopaedic surgeons from western Europe, arranged by the Institute of Orthopaedics, was marred for some of the visitors by the difficulties of language. With this in mind, invitations in 1950 were confined to French-speaking countries, and special efforts were made to have summaries of lectures and demonstrations available in French. The course was extended to ten days, from March 9 to 18, and the four visits to outside centres included a day at the Limb-fitting Centre at Roehampton. A pleasant introduction to the stay in London was a reception given by the British Council and attended by a number of senior orthopaedic surgeons.

The surgeons who attended the course were Drs Cauchoix, Descamps, Estève and Rainaut (Paris), Drs Huwyler and Petri (Zurich), Dr de Cagny (Berck-Plage), Dr de Doncker (Neeryssche, Belgium), Dr Evrard (Montignies-sur-Sambre, Belgium), Dr Ficat (Toulouse), Dr Geneste (Bordeaux), Dr Mulier (Louvain), Dr Muller (Strasbourg) and Dr Van der Elst (Brussels).

There is now every prospect that the course will be established annually, giving some of our junior colleagues from the Continent an opportunity to become acquainted with British teaching and methods.

UNITED STATES OF AMERICA

Philip Wilson Fellowship in Orthopaedic Surgery—A testimonial dinner in honour of Dr Philip D. Wilson, Surgeon-in-Chief of the Hospital for Special Surgery, New York, was given at the Columbia University Club on February 11, 1950, as an expression of the appreciation and respect in which he is held by the men who had their orthopaedic training under his supervision. The occasion was appropriate for the announcement of a permanent tribute to Dr Wilson, in the form of an endowment fund to be known as the Philip D. Wilson Fellowship in Orthopaedic Surgery. The fund will be administered by the Board of Trustees of the Hospital for Special Surgery and the income used for a fellowship at home or a travelling fellowship abroad.

NEW ZEALAND

With great pleasure we report the foundation of the New Zealand Orthopaedic Association. The following officers were elected at the Inaugural Meeting: Patron—*J. Renfrew White*; President—*Alexander Gillies*; Vice-President—*J. Leslie Will*; honorary Secretary-Treasurer—*J. Kennedy Elliott*; Editorial Secretary—*Selwyn Morris*.

The constitution of the new association will be close to that of the British Orthopaedic Association but will, of course, be adapted to the particular conditions of New Zealand.

AUSTRIA

In 1948 Dr W. Ehalt and Dr G. Boehler visited Britain from Austria to attend a course (arranged by the British Council and the Ministry of Health) on rehabilitation and resettlement of the disabled. They now report that a new rehabilitation and resettlement vocational centre has been established under their guidance in Austria. The centre is financed by the Austrian Insurance Board, which administers that country's industrial disability compensation scheme.

Book Reviews

MEDICAL CLINICS ON BONE DISEASES. A Text and Atlas. By I. SNAPPER, M.D. Second edition. Pp. xii+308, with 46 plates. Index. 1949. New York: Interscience Publishers Inc. Price $20. London: Interscience Publishers Ltd. Price £8.

This book has developed from a monograph, first published in Holland in 1938, which dealt with hyperparathyroidism, Paget's disease, the lipoidoses of bone and multiple myelomatosis. The author's wide experience of these disorders was extended even further during his term as Professor of Medicine in Peking; the first English language edition, published in New York in 1943, reflected this and included a new twenty-five page section on rickets and osteomalacia.

The present edition is a very thorough revision, and contains so much new material that it is almost a new book. In the first third, the author's almost classic presentation of hyperparathyroidism is repeated, and the original sections on Paget's disease and on the lipoidoses are not very much changed; but the chapters dealing with osteoporosis of various kinds, with polyostotic fibrous dysplasia, neurofibromatosis and the bone changes in leukaemia, Hodgkin's disease and the haemolytic anaemias are all quite new. There are sections on bone lesions due to biliary fistulae, on parathyroid function in chronic arthritis, and on similar topics. All are accompanied by very full bibliographies and illuminating case reports. The new edition is thus a much more complete atlas of bone diseases than its predecessors.

The best features of this admirable book are the number, the completeness and the quality of the illustrations. The reproduction of radiographs has been superb in all editions, and, in the present volume's collection of well over two hundred prints, not more than ten are imperfect. The standard of the photomicrographs is equally high.

Naturally, not all Dr Snapper's views on pathology will be accepted by everyone, and the orthopaedic surgeon must not be misled by the beauty of the book into thinking that all its ideas of haematology are universally held by specialists in that subject. Yet if some of the theories are unusual, they are at least those of a physician interested primarily in the skeleton; and even unorthodox views on the pathology of myelomatosis must be taken seriously when they come from the introducer of stilbamidine therapy. Those of our profession who are interested in the metabolic and constitutional diseases which affect the skeleton will be enthusiastic about this new edition, and will find it well worth its high price. No teacher of skeletal diseases can afford to be without it.—D. Ll. GRIFFITHS.

AN ATLAS OF AMPUTATIONS. By Donald B. SLOCUM, M.D., M.S., Orthopaedic Surgeon, Sacred Heart General Hospital, Eugene, Oregan; Branch Consultant in Orthopaedic Surgery, U.S. Veterans' Administration. 11 × 9 in. Pp. xiii+562, with 564 figures. Index. 1949. London: Henry Kimpton. Price £7.

The author, an orthopaedic surgeon in Oregan, was formerly chief of the amputation section, Walter Reed General Hospital, Washington. The title suggests a series of illustrations with descriptive legends, but in fact this is an encyclopaedic work containing a mass of information on most aspects of the subject. Its study prompts one to consider what is required of an author of so large a work on the specialised subject of amputations. Probably the most valuable part of the book is that dealing with the convalescent period.

The first section, a brief one headed "Orientation," describes the indications and objectives of amputation. Part II concerns wound healing and surgical preparation; ligation and novocain injection of major nerves are advocated. There follows a chapter on anaesthesia; nerve block is described and illustrated for all the usual areas. (As refrigeration anaesthesia has a place in surgery, a detailed description would have been useful.) Part III provides a mass of detail on open and closed amputation. The subject of open amputation and disarticulation is described and illustrated thoroughly, and will prove useful to those dealing with accidents and war surgery. The author's indications for this operation are somewhat generous: since the introduction of antibiotics they have been narrowed. There is but brief mention of the systemic use of penicillin, and the author finds no advantage in its local application. The local use of Dakin's solution and saline packs is approved. The circular amputation is preferred, but flap operation is described. The methods of limiting skin retraction are clearly stated. In dealing with routine amputations, many types are described, some of them obsolete in Britain. Cineplastic amputation is stated to be little used in America, and the unsightliness of the Krukenberg operation does not encourage its use. A valuable contribution is made to the surgery of the hand. In Part IV there is a chapter on the convalescent period, including the

hygiene of the stump and care of stump socks. Useful experience of complications in the stump is reported. Those who make a study of amputations will be well rewarded by reading the chapters on body mechanics and posture, and the well-illustrated section on the mechanics of walking. Exercises and education in the use of a prosthesis are on the same lines as in Britain. Wooden sockets are favoured; there is also mention of plastics and suction sockets.

This book is written out of great experience, particularly of war amputees. The nomenclature of various operations differs from our own, and in some cases modern surgeons' names replace those well established. The name of Farabeuf has disappeared, but Chopart and Lisfranc remain. British readers will be surprised to find no mention of Gordon-Taylor, although two methods of removing the "hindquarter" are mentioned. The choice of amputation, when required after sympathectomy for peripheral arterial disease, would have been an interesting topic.

The illustrations are excellent and the production above criticism; large pages allow photographs to be reproduced in a generous and valuable size. There are many references, but the omissions of some British work is surprising. This book should have a place in all orthopaedic libraries.—St J. D. BUXTON.

ON THE CONTRIBUTIONS OF HUGH OWEN THOMAS, SIR ROBERT JONES, JOHN RIDLON, M.D., TO MODERN ORTHOPEDIC SURGERY. By H. Winnett ORR, M.D., Chief Surgeon, Nebraska Orthopedic Hospital, Linclon, Nebraska. With a Supplement on RIDLON AND HIS SHARE IN MOULDING ORTHOPEDIC SURGERY by Arthur STEINDLER, M.D., Professor of Orthopedic Surgery, State University of Iowa Medical School, Iowa City, Iowa. 8½×6½ in. Pp. xiv+253, with 22 figures. Annotated bibliography. 1949. Illinois: Charles C. Thomas. Oxford: Blackwell Scientific Publications Ltd. Price 25/–.

Dr Winnett Orr is to be congratulated on the insight, knowledge and judgment which he has brought to this study. He has drawn a picture as clear in detail as it is accurate in perspective. Many books instruct one's mind and improve one's outlook, but few are so pleasant and easy to read as Dr Winnett Orr's. Any criticism that might be made would be so minor as not to merit the space it would occupy. Every orthopaedic surgeon would be well advised to read and consider this book.—B. L. MCFARLAND.

LORD LISTER. His Life and Doctrine. By Douglas GUTHRIE. 9×6 in. Pp. viii+128, with 20 plates and one colour illustration. Index. 1949. Edinburgh: E. & S. Livingstone Ltd. Price 15/–.

This book is important and interesting. It is not a conventional biography, nor does it try to be one. Instead, it concentrates on Lister's teaching far more than upon the life and character of the man himself. The reassessment is valuable and opportune: in the light of all the changes in surgical thought since the antiseptic principle was first announced, Lister's achievement is shown to be even greater than most of us think. It is astonishing that the greatness of the achievement was recognised in his lifetime while so much of the fundamental basis of his teaching was completely misunderstood, and, for that matter, still is. The book has the pleasant style which Dr Guthrie's readers have come to expect; it is well-balanced and written with due regard to Lister's background. His Quaker upbringing, the family interest in general biology, his education, his first researches and his interest in surgery for its own sake are well brought out. One feels that this book, in which his doctrine is made more important than his life, is just the sort of biography Lister would have wanted. Naturally it does not replace other works. A quarter the length of Godlee's biography, it is at once less detailed, more critical and more modern. It lacks the personal touch and intimate character of Cameron's account published in 1948. At the same time Guthrie's book contains some valuable and hitherto unpublished Listeriana, and is to be recommended very strongly to all surgeons. —D. Ll. GRIFFITHS.

ANKYLOSING SPONDYLITIS. Part I by F. HERNAMAN-JOHNSON, M.D., F.F.R., D.M.R.E., Physician, Charterhouse Rheumatism Clinic; Consulting Radiologist to the French Hospital and Dispensary. Part II by W. Alexander LAW. O.B.E., M.D., F.R.C.S., Assistant Surgeon, Orthopaedic Department, London Hospital; Consulting Orthopaedic Surgeon, Charterhouse Rheumatism Clinic. 8½×6 in. Pp. viii+200, with 41 figures. Index. 1949. London: Butterworth & Co. (Publishers) Ltd. Price 25/–.

In his introduction Hernaman-Johnson pays tribute to Gilbert Scott's demonstration of the radiological changes in the sacro-iliac joints which are the earliest evidence of the onset of ankylosing spondylitis. The pathology, particularly the morbid anatomy, is scantily described; the classical accounts, by Marie, Strumpell and Lawford Knaggs, are not mentioned and the authors remark: "The post-mortem room has so far added little to our knowledge of spondylitis: what we know of pathology is mostly the result of radiographic investigation." The technique of treatment by X-rays is described and discussed in a detailed and

well-informed way, although the recommendations may be questioned by other radiotherapeutists of standing. It is in the assessment of the results of this form of treatment that the work is disappointing. Hernaman-Johnson states that he and Gilbert Scott have used X-ray therapy in " well over 1000 cases," yet no statistical information is given other than some results of Foster and Gillespie, of Boston, which " correspond with those of my own experience." Again, in a discussion of some length on familial incidence, the researches by West, of Bristol, are quoted rather than personal figures. The book contains interesting dissertations on the general management of the patient, on what may be termed the sociological features of the disease, and on the diverse and disappointing methods of treatment with vaccines and drugs.

Alexander Law describes the role of the orthopaedic surgeon in the management of ankylosing spondylitis, but is more concerned with reconstructive surgery than with conservative methods. Such things as plaster beds, head traction and exercises are referred to, but not in the detail that might be expected in a monograph of this size; the " long spinal support " is mentioned without any comment on those mechanical factors which render it such an uncertain aid in ankylosing spondylitis. The descriptions of operative technique are clear, and the case summaries are of great interest and value. Some of the illustrations are not up to modern standards, for example Figures 6, 17, 25 and 27; otherwise Messrs Butterworth and the authors may be congratulated on a well-produced and readable text.—W. D. COLTART.

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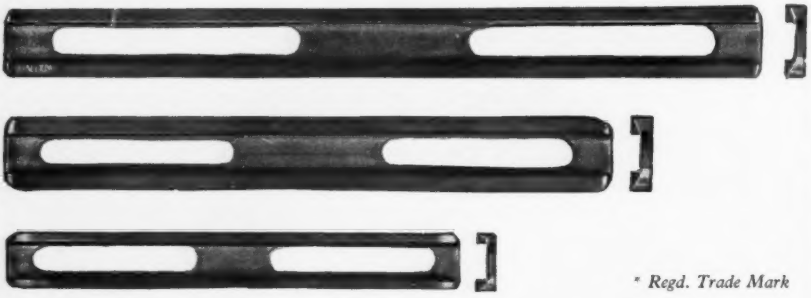

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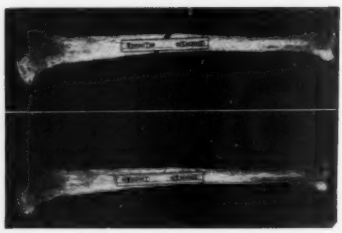

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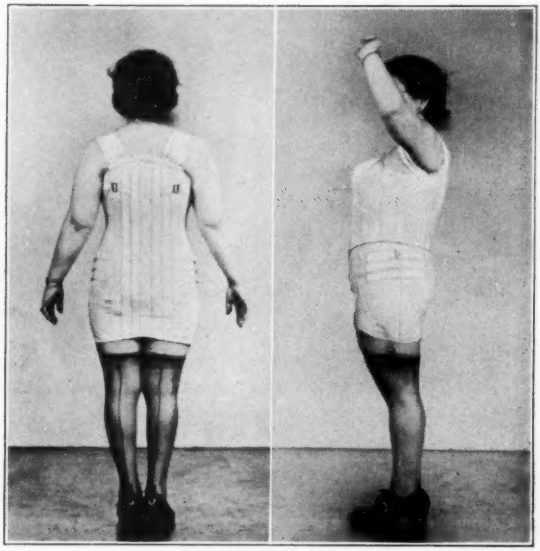

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Fig. 1

Fig. 2

Fig. 3

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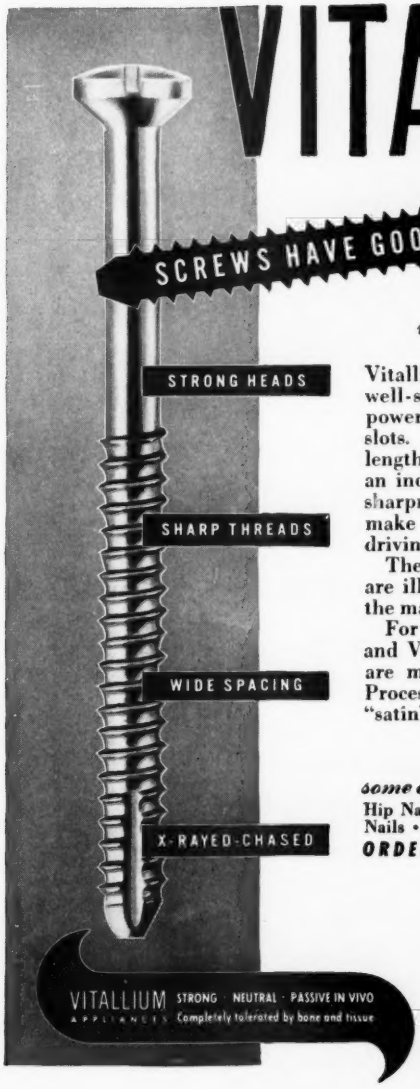

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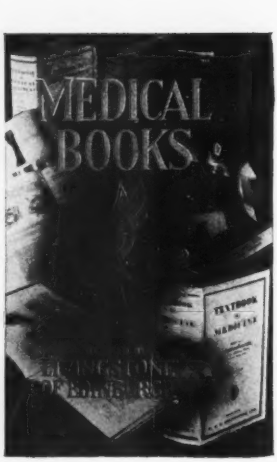

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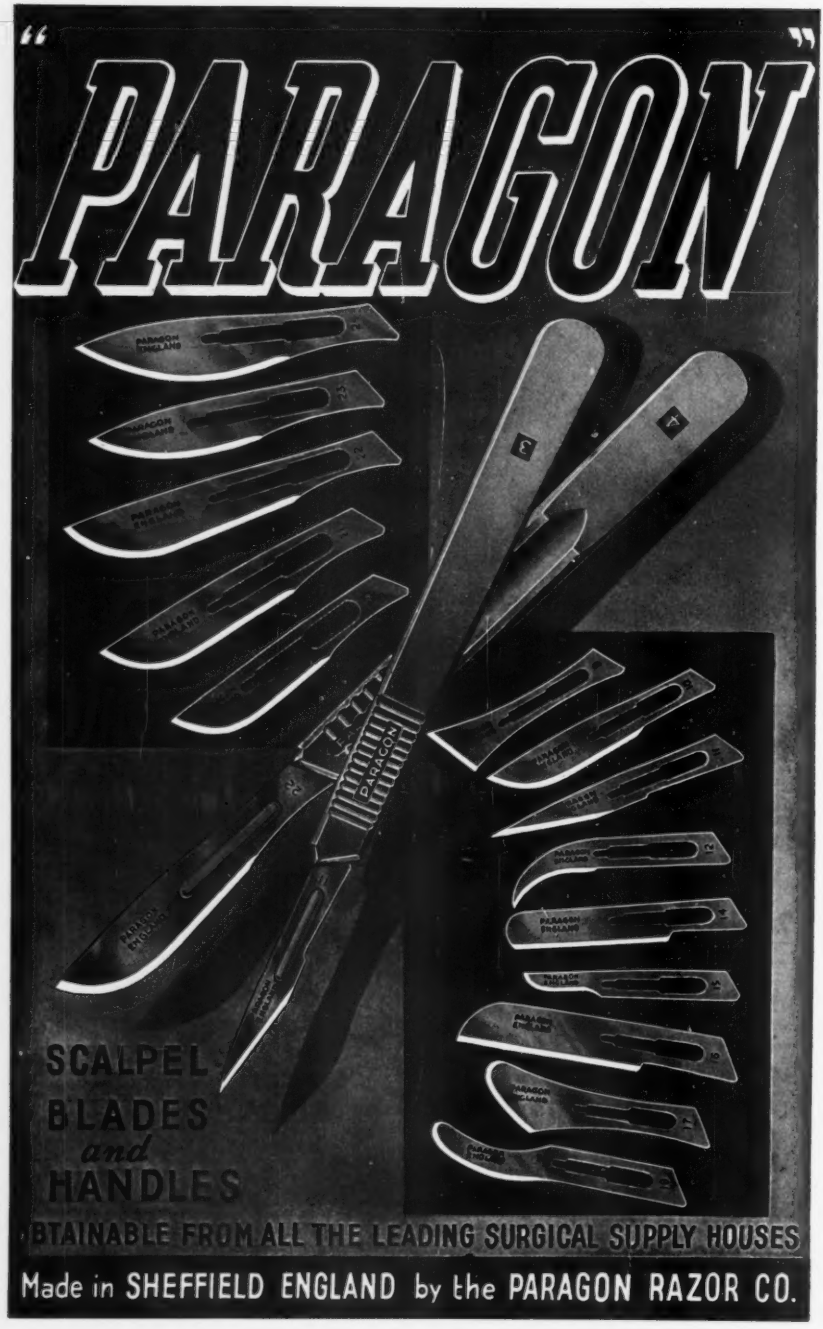
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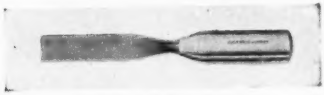

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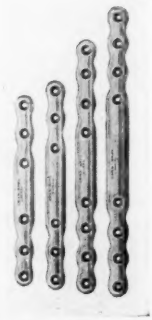

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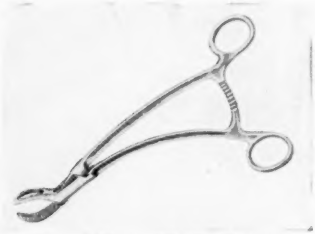

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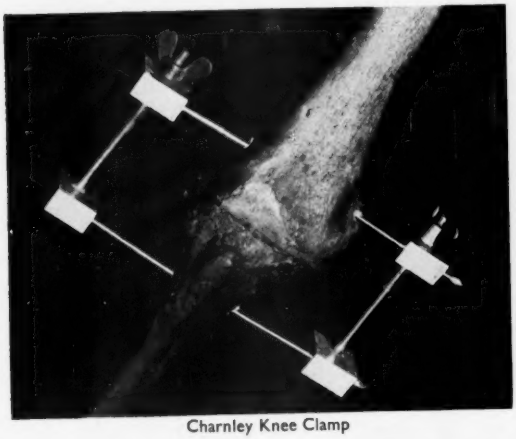

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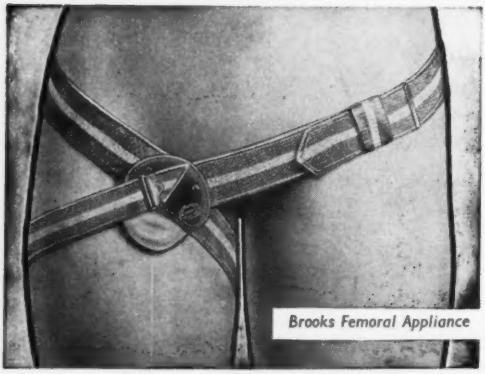

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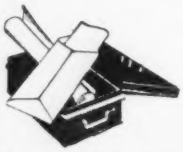

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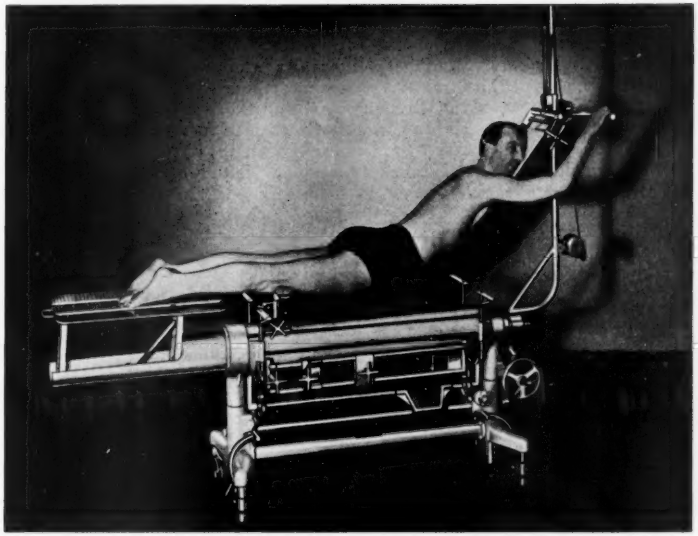

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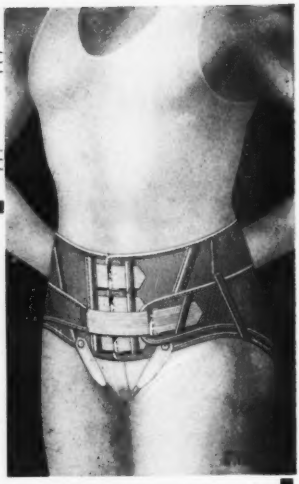

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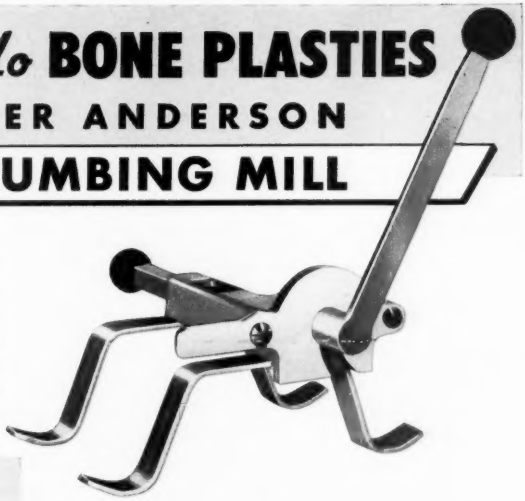

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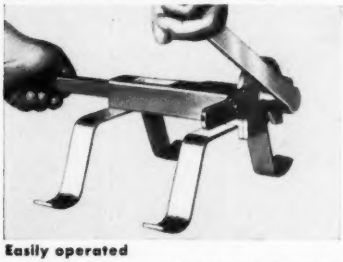

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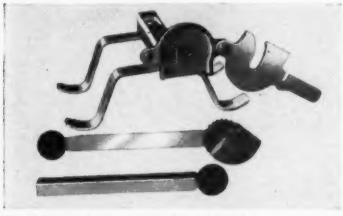

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